REPORT RESUMES

ED 010 639 24

ECONOMICS OF GRADUATE EDUCATION--AN EXPLORATORY STUDY.

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REPORT NUMBER CRP-2852 PUB DATE NOV 66
REPORT NUMBER BR-5-0855
CONTRACT OEC-5-10-244
EDRS PRICE MF-$0.18 HC-$4.24 106P.

DESCRIPTORS- *ESTIMATED COSTS, *STUDENT COSTS, EDUCATIONAL FINANCE, *GRADUATE STUDY, EDUCATIONAL RESEARCH, GRADUATE STUDENTS, *DOCTORAL PROGRAMS, FINANCIAL PROBLEMS, PUBLIC SUPPORT, *ECONOMIC RESEARCH, ECONOMIC FACTORS, ANN ARBOR, MICHIGAN

AN ATTEMPT WAS MADE TO DEVELOP A SINGLE SET OF DEFINITIONS, CONCEPTS, AND MEASUREMENT TOOLS TO BE APPLIED UNIFORMLY TO COST ANALYSES OF FOUR PH.D. PROGRAMS IN PHYSICS, ZOOLOGY, SOCIOLOGY, AND ENGLISH. TO GATHER THE REQUIRED INFORMATION ON THE NATURE OF THE COST ESTIMATES WHICH ARE IMPLICIT IN THE SUBSEQUENT RATE OF RETURN ANALYSIS, SITE VISITS WERE MADE TO 12 UNIVERSITIES. THE RESEARCH PHASE OF DOCTORAL PROGRAMS WAS DELINEATED AND ITS COST AS A COMPONENT OF THE TOTAL COST OF TRAINING PH.D.'S WAS ESTIMATED. IN ADDITION, OPPORTUNITY COSTS, COSTS OF UTILIZING PHYSICAL FACILITIES, AND THE INDIRECT OR SUPPLEMENTAL COST ELEMENTS WERE ESTIMATED. TABLES OF MEASURABLE RELATIVE RATES OF RETURN TO GRADUATE EDUCATION WERE CONSTRUCTED. WHILE THE RELATIVE MAGNITUDES OF UNMEASURED EXTERNAL CONTRIBUTIONS MADE BY THE PH.D.'S UNDER STUDY WERE NOT IDENTIFIABLE, THE MEASURABLE FINDINGS POINTED TO LOWER INVESTMENT YIELDS FOR ENGLISH AND SOCIOLOGY PH.D'S. IF BOTH DOCTORAL PROGRAMS COULD BE ACCELERATED, THEN THE NUMBER OF YEARS THAT ONE WOULD HAVE TO FOREGO INCOME WOULD BE LESSENED. WHILE THE COST OF TRAINING PER YEAR OF GRADUATE STUDY WOULD NOT GO DOWN, OPPORTUNITY COSTS, AND THEREFORE TOTAL COSTS, WOULD BE LESSENED. ALTHOUGH ACCELERATED PROGRAMS WOULD SERVE TO NARROW THE DIFFERENTIALS BETWEEN RATES OF RETURN OF THE NATURAL SCIENCES AND THOSE OF ENGLISH AND SOCIOLOGY, THIS ADJUSTMENT BY ITSELF WOULD NOT LIKELY BRING THE RATES OF RETURN INTO EQUILIBRIUM. (GD)

ED010639

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FINAL REPORT
Cooperative Research Project No. 2852
Contract No. OE-5-10-244
Bureau No. 5-0855

Economics of Graduate Education: An Exploratory Study

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November 1966

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education
Bureau of Research

ECONOMICS OF GRADUATE EDUCATION: AN EXPLORATORY STUDY

Cooperative Research Project No. 2852
Contract No. OE-5-10-244

Irene H. Butter

November 1966

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ACKNOWLEDGMENTS

The study here reported was made possible by the cooperation and assistance of numerous individuals at twelve universities, including graduate deans, vice presidents, chairmen, and graduate faculty of the four surveyed disciplines, as well as secretaries and many others. Without the support provided by all these individuals this study would not have been feasible.

Especially during the planning stage but also during subsequent phases, Dr. John E. Swanson, Director of the University Study, Institute of Public Administration, The University of Michigan, contributed substantially to the design and procedures of the study. His generous advice and support call for special gratitude. Professor Lee R. Martin, School of Natural Resources, The University of Michigan, offered valuable suggestions and critical advice on many occasions, and these were of significant value to the investigator.

Credit should also be given to Dennis Burke who contributed to many phases of the exacting process of tabulating, processing, and analyzing the data.

The study was supported by the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare.

Irene H. Butter

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CHAPTER I

INTRODUCTION

The costs of different types and levels of education, as well as the returns from educational expenditures, are receiving a growing amount of attention from economists, school administrators, and policy makers. A number of economists have turned to estimating the costs of different levels of education, and have used the available data on earnings by age and education to produce rate of return calculations. Such calculations indicate that the returns to educational investment are uneven with respect to different levels or segments of education. Thus an interest has been developed in trends of the rates of return over successive increments of educational attainment.

This report describes the analytic framework and findings of a study on costs and returns of graduate education. It differs from other economic studies on costs and returns of education in that it focuses exclusively on the graduate level of education, and more specifically, on doctoral programs in four disciplines. Moreover, an attempt is made in this study to calculate separate rates of return for different employment possibilities that avail themselves to doctorate holders in these four disciplines.

The present study was undertaken with the assumption that estimates of the training cost of Ph.D.'s and also the estimates of returns on investment in graduate study are needed for the pursuit of policy objectives at the state, regional, and federal level and also at the level of private educational foundations. It was presumed that a society which allocates a sizable and growing volume of public and private resources to graduate education is bound to generate an increasing demand for this type of information. Up till now decisions made within the educational system were based on very limited and extremely crude information on the costs and returns of doctoral programs. Inasmuch as the study here reported is of an exploratory nature, its findings are also limited in scope and validity. However, though the information compiled and presented constitutes a first approximation, it makes possible the provisional delimitation of ranges of costs and returns for graduate education in four selected disciplines.

In this study investment in graduate education is viewed as human capital formation. Moreover, graduate departments of a university are viewed as enterprises analogous to business firms, engaged in combining various inputs to produce multiple products. The real inputs to be considered consist of goods such as: buildings, supplies, equipment, and library materials; as well as of services such as those supplied by students, teachers, and administrative and clerical personnel. Inasmuch as interest is focused on the total social cost of Ph.D.'s, rather than on the consumers' cost or the suppliers' cost, the relevant financial inputs include expenditures financed by the institution, as well as those financed through subsidies from outside sources.

Identical inputs are employed by a university department to produce a multiplicity of services including: undergraduate training, graduate training, production of new knowledge, selection and encouragement of potential talent, and recruitment and instruction of potential teachers. Inasmuch as joint production is basic to the productive processes carried out by university departments, one of the major tasks of this study is the identification, allocation, and measurement of all costs that enter into graduate training per se. In the analysis of the graduate training function of a department annual output will be measured in units of graduate student credit hours produced. Thus the analysis of the cost of training Ph.D.'s constitutes the first part of this study.

The cost analysis of investment in graduate education is followed by an examination of the investment returns. The rate of return analysis addresses itself to questions of efficiency in resource allocation with respect to competing uses. On the assumption that a person's productive contribution to output is reflected by his earned salary, rates of return calculated for individual professions presumably indicate the relative contribution to the economy resulting from graduate education in one discipline as compared with others, as well as the contribution of graduate education relative to that of other types and levels of education. In this study, the rates of return to the investment in four types of Ph.D.'s will be ranked and compared to rates of return estimated for prior levels of education.

This study concentrates entirely on the social rate of return, which differs from the private rate in that it is based on total social costs of education and the before-tax net earnings differentials associated with education, in contrast to the private rate which is calculated with respect to private costs and after-tax earnings differentials. Whereas the private rate of return can be a basis for individual decision making in regard to choice of profession involving a Ph.D. degree, the social rate of return may be considered relevant to the clarification and possible modification of aspects of educational policy. Information on the social yield of educational investment may contribute objectivity to consideration of such issues as the following:

(1) Should more or less resources be allocated to graduate education relative to other forms of education, such as high school, college, or vocational training, or relative to other noneducational forms of investment.

(2) Given the allocation of additional resources to graduate education is considered desirable, how should these be financed, and where are these resources likely to result in highest yields.

(3) Assuming that federal and state appropriations for graduate education are to remain constant, can increased economic benefits be derived from a redistribution of funds between different areas of investigation.

The above are merely illustrations of the type of issues faced by decision makers in the realm of educational policy. There are numerous other issues related to problems of resource allocation in education.

The argument that social yields of educational investments are relevant to policy decisions, should not be misconstrued as a belief that economic considerations alone are or should be the overruling determinants of resource allocation to education. Potentially education has other than economic impacts on a society, and these extra-economic effects may be equally or even more important than the maximization of net national product. Nevertheless, the role of noneconomic factors need not be weakened or overshadowed by recognition of the economic implications of education.

Some parts of this study draw on concepts and procedures developed in several other studies. The association between this study and related inquiries will be pointed out in the appropriate sections of this report. At this point a very brief review of related literature will be presented. Recent efforts of economists in the area of education may be grouped into three types of inquiries:

1. Development of a conceptual framework and of estimating procedures for an analysis of investment in education. T. W. Schultz contributed a number of pioneering studies in this area comprising the measurement of resources entering into the different levels of education, the measurement of the stock of capabilities developed by education. and measurement of the rates of return.*

2. Analytical studies attempting to identify and measure a variety of returns from educational investment. Becker, Hansen, and Weisbrod have been the leading contributors to analysis of re-

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*T. W. Schultz, "Capital Formation by Education," Journal of Political Economy, December, 1960, and "Education and Economic Growth," Social Forces Influencing American Education, 1961; Fritz Machlup, Production and Distribution of Knowledge in the United States, 1962.

turns and benefits.*

3. Attempts have been made to refine the rate of return approach by correcting for ability as well as for a number of other factors which influence both education and income. This type of approach has stimulated multiple correlation studies of income determining variables and studies conducted along these lines have explicitly recognized the intercorrelation between education and other income-determining variables. These studies after having adjusted for such variables as differential abilities and endowment suggest that education is substantially even if not totally responsible for net earnings differentials between the more and the less educated.**

Previous economic studies on the social cost of pregraduate levels of education addressed themselves to the calculation of an annual average cost per student derived from broad aggregate educational expenditures. The gathering of data from individual educational institutions was not required for estimates of this type. However, the problems of measuring per student costs of graduate education are more complicated for two main reasons. Graduate education is closely interrelated with undergraduate training and elaborate procedures are needed to separate the graduate cost of those inputs jointly used for graduate and undergraduate programs. Furthermore, there are good reasons for presuming that the costs of doctoral programs vary significantly between fields of study. Since it is attempted in this study to calculate comparative rates of return to the investment in Ph.D.'s in four fields of study, it is necessary to determine the differences in the cost of training Ph.D.'s in these four disciplines. It is clear that such differences can be assessed only on the basis of intensive cost analyses of these four doctoral programs as offered in a sample of centers of graduate education.

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*Gary S. Becker, "Underinvestment in College Education," American Economic Review, May, 1960; Human Capital, New York, 1964; W. Lee Hansen, "Total and Private Rates of Return to Investment in Schooling," Journal of Political Economy, April, 1963; Burton A. Weisbrod, "Education and Investment in Human Capital," Journal of Political Economy, October, 1962, External Benefits of Public Education, Princeton, 1964, Weisbrod and Swift, William J., "On the Monetary Value of Education's Intergeneration Effects," Journal of Political Economy, December, 1965.

**Harvey E. Brazer and Martin David, "Social and Economic Determinants of the Demand for Education," in The Economics of Higher Education, Selma Mushkin, ed., Washington, D.C., 1962; James Morgan and M. David, "Education and Income," Quarterly Journal of Economics, August, 1963; Gary S. Becker, Human Capital, Dael Wolfle, America's Resources of Specialized Talent, New York, 1954; Shane J. Hunt, "Income Determinants for College Graduates and the Return to Educational Investment, Yale Economic Essays, 1964.

It is known that institutions of higher education make use of different concepts, terminology, analytic procedures, and accounting systems in their recording and analyses of operations for internal purposes. It is therefore not feasible to make interinstitutional comparisons of costs as calculated with procedures peculiar to each individual institution. In this study, uniform concepts, methods, and procedures were applied to raw data gathered on variables basic to the doctoral programs in each of the four disciplines.

One purpose of the study to be reported is to determine the feasibility of identifying and measuring the costs of training Ph.D.'s in four disciplines. It was necessary to consider whether the information, which is essential to this type of a cost analysis was always retrievable despite the wide variation in existing record-keeping practices of universities. The survey for this study included twelve institutions comprising universities that are known to have relatively elaborate records for financial analysis, universities that are known to have average quality records, and institutions with a reputation for having neglected the recording of types of information required for this study. It was hoped that the inclusion of universities which to date had placed different degrees of emphasis on the recording and analysis of their operations, would make it possible to test the feasibility of collecting the required data under the most favorable as well as under the least favorable circumstances.

Objectives other than determining the feasibility of obtaining the required data on the cost of doctoral programs include the following:

(1) To present estimates of the total cost and of component costs of graduate training in four disciplines for twelve universities.

(2) To carry out statistical analyses on the cost calculations in order to determine some of the factors responsible for variation of the average cost per Ph.D. within and between disciplines.

(3) To present estimates of the average opportunity cost of a Ph.D. in each of the four disciplines and to compare the opportunity costs of graduate education with previously estimated opportunity costs of prior levels of education.

(4) To estimate rates of return to the investment in four different Ph.D. programs, as well as comparative rates of return for different types of employment chosen by Ph.D.'s in a given discipline.

(5) To compare the rates of return estimated in this study with rates of return computed by other economists for preceding levels of education.

This list of objectives indicates that a major portion of the study focuses on the development of concepts, data gathering methods, and data analyses requisite to the derivation of cost estimates. Thus a major portion of this report also concentrates on the nature of the cost estimates which are implicit in the subsequent rate of return analysis.

CHAPTER II

THE SAMPLING AND PROCEDURES OF THE STUDY

The first portion of this study concerns itself with the estimation of total social costs of training Ph.D's in several different subject areas, namely, the physical sciences, biological sciences, social sciences, and the humanities. These four different subject areas were included in the study in order to explore the range of interdisciplinary variability in the cost of graduate education. One academic field within each subject area was then selected for cost analysis, and the choice of four disciplines was based on the following criteria:

(1) It was necessary that at least twelve universities offer Ph.D. programs in the four selected disciplines.

(2) Doctoral programs of the four disciplines in each of the twelve institutions had to be offered by departments under the auspices of the same college or school of the university. For example, if only six academic physiology departments exist in the entire country, while Ph.D. degrees in physiology are awarded by medical schools of other institutions, then physiology could not be included in the study. This criterion was dictated by the complications of data-gathering and by the lack of uniformity in the academic calendar, academic requirements, and in the crediting and accounting procedures of graduate and professional schools of the same university.

(3) Selection was aimed at disciplines which lend themselves to clear and uniform definition, avoiding disciplines in which different departments tended towards strikingly different orientations.

On the basis of these criteria Physics, Zoology,* Sociology and English were chosen to represent the four broader subject areas mentioned above.

To gather the required information site visits were made to a sample of twelve universities and the following represent major factors which entered into selection of the sample:

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*In four out of the twelve universities included in the study the Ph.D. degree in Zoology was offered in a department of Biological Sciences. In those instances the Zoology program did not constitute a separate entity and therefore the entire department of Biological Sciences was surveyed.

1. geographical distribution
2. variation in size
3. type of control, i.e., public vs. private
4. inclusion of institutions with a reputation for relatively good, mediocre, and less adequate record keeping practices and financial analysis.

For two reasons it was considered desirable to gather data from a heterogeneous sample of universities. Since one of the objectives of the study is to determine the feasibility of obtaining all essential data for calculations of graduate training costs by discipline it was necessary to include institutions which employ accounting systems of varying comprehensiveness. Furthermore, it was felt that in order to make the estimates of average total costs of training Ph.D's as representative as possible for the graduate training programs of a given discipline, the data on which the estimates are based should be gathered from a group of departments of considerable heterogeneity. Along with variation in the four above criteria which governed selection of the sample, participating institutions and departments are also diverse with respect to available indices of quality.*

At an early stage of the study a sample of twelve universities was selected in accordance with above criteria and letters were sent soliciting their cooperation. Five schools in the initial group declined to participate in the study. An inquiry was then made to determine how many of the remaining eligible universities who offer Ph.D. degrees in all four disciplines, would be willing to participate in the study. Of the thirty-three institutions contacted twelve accepted, fourteen declined, and seven failed to reply. In total, forty-five universities were approached, of which nineteen accepted, nineteen declined, and seven failed to respond.

The final sample consists of seven public and five private universities, four of which are in the East, six in the Midwest, and two in the West. Mainly for the following reasons one of the participating universities was later omitted from the study: the fulfillment of degree requirements with respect to the earning of credit hours by graduate students was so different from all other included universities that a comparable curriculum analysis could not be carried out; also at this university one of the four departments failed to return any of the distributed faculty time distribution questionnaires. The data gathered at this university were excluded from all tables and all the estimates and average figures presented in this report are based on eleven observations for each discipline.

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*A recent index was compiled during 1964; Allan M. Cartter, An Assessment of Quality in Graduate Education, American Council on Education, Washington, D. C., 1966.

The following costs were considered to be basic in determining the total cost of graduate education:

1. Instructional costs consisting of:
    (a) graduate faculty salaries
    (b) staff benefits
    (c) departmental supplies, equipment, and clerical costs
2. Research costs, derived partially from expenditures for sponsored research projects conducted by graduate faculty
3. Costs of physical facilities
4. Administrative costs, including both general university and departmental administration
5. Library costs
6. Opportunity costs

These six items represent the major elements of the cost of graduate education. Additional costs may be identified, such as the cost of books purchased by students, the cost of computer time used for graduate student research and dissertations, the cost of typing dissertations, travel, etc. These expenditures were explicitly omitted from the present study, partly because they are relatively small, but mainly because the information would have to be obtained from individual students, while students were not contacted for any other part of the study.

Site visits were made to all participating universities to gather data pertaining to the six items above for the year 1964-65. Essentially three basic categories of information were compiled:

1. Student Data: All available information on a sample of 20-25 most recent Ph.D. recipients of each department consisting essentially of transcripts, duration of graduate study, employment and fellowship data. Student data were used to derive a so-called "representative curriculum" for doctoral students of each department based on (a) the average total number of credit hours earned for the Ph.D. degree, and (b) a break-down of the total credit hours into average number of course credit hours and average number of thesis or research credit hours. In this study costs per Ph.D. are calculated with respect to number of credit hours earned for the degree by the student. For this reason the "representative curriculum" is essential to the cost calculation. The employment and fellowship data were used in estimating the opportunity cost of the Ph.D. Major aspects of the curriculum data are summarized on Table 1.

2. Faculty Data: Data on time distribution of the workweek of graduate faculty among graduate and undergraduate instruction, research, graduate student

TABLE 1

SUMMARY OF STUDENT AND CURRICULUM DATA

Universities	Total Semester Credit Hours Earned				Percent of Credit Hours Spent in Research				Number of Years for Ph.D.				Full Time Equivalent Years of Employment*			
	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English
A	92.1	109.9	86.4	93.8	42	40	27	31	4.8	6.0	5.3	7.4	1.6(0.0)	1.0(0.2)	1.4(0.4)	2.1(1.0)
B	83.4	98.7	91.3	97.5	38	43	23	42	5.5	6.1	9.5	7.9	1.5(0.0)	3.1(1.0)	5.1(4.4)	3.2(2.6)
C	57.8	81.2	80.7	78.2	26	36	10	9	7.3	6.1	8.4	8.5	3.1(2.0)	1.0(0.6)	2.7(1.9)	3.6(2.6)
D	67.9	83.6	74.9	75.2	25	28	25	19	5.5	7.4	6.5	8.5	1.5(0.1)	1.4(0.0)	1.7(0.9)	3.0(2.7)
E	114.2	127.9	111.5	127.1	30	34	23	23	5.8	6.3	6.6	8.7	1.5(0.0)	2.3(0.4)	1.3(0.3)	2.5(2.4)
F	143.6	138.9	101.1	113.2	57	49	34	39	6.6	6.6	7.0	7.6	3.1(0.0)	1.9(0.0)	1.9(0.5)	3.8(0.1)
G	91.4	106.2	101.5	90.6	41	36	36	32	5.2	7.4	6.3	7.7	1.5(0.0)	2.6(1.8)	1.5(0.3)	2.6(1.8)
H	74.7	88.5	89.7	70.5	36	55	28	17	5.8	7.9	7.5	6.8	2.3(0.0)	3.9(2.9)	3.5(1.8)	3.3(2.2)
I	80.0	81.8	65.3	62.7	41	49	13	9	7.2	6.7	9.9	10.7	1.2(0.0)	----	----	----
J	73.2	82.5	83.4	88.2	16	17	10	14	5.9	6.6	7.7	8.8	3.1(0.2)	1.7(1.2)	2.9(2.3)	5.8(3.8)
K	111.6	128.6	98.0	95.0	58	51	35	49	6.0	6.6	6.2	8.7	3.1(0.0)	2.4(0.4)	2.1(0.1)	3.5(2.4)
Avg.	90.0	102.5	89.4	90.1	37	40	24	25.8	5.9	6.7	7.4	8.3	2.1(0.2)	2.1(0.8)	2.4(1.3)	3.3(2.2)
Wt. Avg.	87.6	99.6	87.2	87.3	34	38	23	25	5.8	6.6	7.2	8.1	2.1(0.1)	2.0(0.8)	2.3(1.1)	3.2(2.1)
Std. Dev.	14.8	12.1	13.3	18.7	12.9	16.7	10.5	13.7	0.7	0.6	1.9	1.0	----	----	----	----

*The figures within parentheses represent years of employment away from graduate school. These years are included in figures outside the parentheses.

supervision, administration, and other professional activities.* These data were primarily used in allocating graduate faculty salaries between graduate course instructional cost, graduate student supervision cost, research cost, and departmental administration cost. Faculty time distribution data are summarized on Table 2.

3. Departmental Data: Current year data for each department on all relevant inputs and outputs that constitute the graduate program. The basic procedure used here for cost calculation involves determining separately for each department the costs of "producing" a credit hour in 1964-65 and subsequently multiplying all cost elements by the number of credit hours earned by the typical doctoral student of each department. The procedure is then applied separately to course credit hours and the costs related to the course-taking phase of graduate study; to research or thesis credit hours and the costs related to the research phase of graduate study; and to the total number of credit hours and all indirect or supplemental costs related to the entire doctoral program on a credit hour basis.

Some specific aspects of the cost analysis deserve additional elaboration. An explicit statement of certain built-in limitations of the cost estimates which follow will further clarify the procedures employed in the analysis of costs. All components of the total cost of training Ph.D.'s, except the students' income foregone, are calculated on a cost per student credit hour basis, with respect to expenditures made and graduate student credit hours produced by a department in 1964-65. The 1964-65 cost per credit hour figures are combined with the "representative curriculum" derived for each department on the basis of a sample of recent Ph.D. recipients. Inasmuch as costs per credit hour are likely to change from year to year the total cost estimates presented are neither a precise measure of the total cost of training graduate students enrolled during 1964-65 who will receive their degrees in future years, nor is it a precise measure of the total cost of training recent Ph.D. recipients, who earned their credit hours during years prior to 1964-65. A more exact cost analysis, which takes into account yearly variation in prices of inputs and variability in the volume of outputs of a department, could be derived from data gathered for the entire period of graduate study of a cohort of doctorate holders. The present study was not designed to attain such duration and scope.

The estimates presented in this study measure the total cost of training a specific group of Ph.D.'s under the following conditions:

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* The questionnaire which was used is reproduced in the Appendix. Questionnaires were distributed during the site visits to all faculty members involved in graduate training during 1964-65. Follow-up questionnaires were mailed later to non-respondents. The number of usable responses constitute an average of 73.2% in Physics, 71.6% in Zoology, 71.0% in Sociology, and 61.8% in English.

TABLE 2

FACULTY TIME DISTRIBUTION DATA

Universities	Work Week				Graduate Instruction				Research				Graduate Student Supervision				Undergraduate Instruction				Administration				Other			
	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English	Physics	Zoology	Sociology	English
														In Hours														
A	55.0	57.5	54.4	--	9.8	8.3	9.6	--	15.8	18.7	21.7	--	10.4	4.8	3.1	--	11.1	15.1	12.3	--	5.2	6.0	4.6	--	2.3	4.5	3.1	--
B	56.8	58.2	54.0	55.0	7.3	6.5	12.1	12.8	19.6	17.0	16.0	11.5	13.3	4.8	3.8	6.1	6.7	15.0	10.5	8.2	6.1	7.8	7.5	8.5	3.2	6.6	3.8	7.7
C	54.1	55.1	64.0	52.8	10.7	7.8	10.3	8.4	22.8	19.9	19.0	10.6	4.5	5.1	4.8	1.4	8.2	8.3	12.4	24.5	5.9	10.5	8.3	6.0	2.1	3.4	9.6	1.9
D	51.7	56.2	60.0	59.1	7.2	6.6	7.0	5.8	18.9	15.9	18.1	10.2	5.9	3.0	4.9	2.8	10.0	18.8	8.9	28.3	7.8	5.5	15.5	5.1	1.6	6.3	5.2	6.6
E	60.8	50.2	49.6	57.0	10.3	8.6	10.6	13.3	26.7	19.3	17.3	19.6	9.0	5.1	2.1	3.2	8.5	11.3	10.7	10.7	3.3	4.7	4.3	7.8	2.9	1.2	4.4	2.2
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G	58.0	49.0	55.0	51.0	8.1	6.0	9.0	11.0	24.0	18.0	15.0	12.0	9.0	4.9	4.3	4.2	8.7	5.0	7.0	11.0	6.1	10.0	17.6	10.0	1.0	4.6	2.0	2.0
H	57.9	56.7	49.9	56.7	7.2	4.2	6.6	11.2	22.5	25.1	23.1	10.4	10.4	5.2	4.9	5.4	8.4	8.3	7.4	15.6	5.5	7.2	5.0	12.2	3.7	6.8	3.0	1.8
I	54.9	49.3	61.0	56.5	3.8	3.9	8.4	10.2	30.0	26.2	30.4	10.6	9.0	4.9	6.0	3.4	3.8	4.2	3.0	8.7	4.1	4.0	6.3	17.9	4.0	6.0	7.1	4.7
J	54.1	50.9	61.1	56.8	5.9	6.5	11.3	15.3	21.9	15.9	21.3	9.1	6.7	4.5	4.5	3.6	5.6	26.0	10.4	17.4	5.5	9.5	8.2	9.0	3.9	4.5	5.4	2.2
K	54.9	54.9	53.2	55.3	3.9	6.8	8.2	11.3	15.5	19.1	11.0	14.7	11.5	4.4	8.2	4.1	12.5	10.4	11.9	15.3	6.8	6.0	7.2	8.4	4.6	8.0	7.1	1.4
Avg.	55.8	53.8	56.3	55.6	7.4	6.5	9.3	11.0	21.8	19.5	19.3	12.1	9.0	4.7	4.7	3.8	8.4	12.2	9.5	15.5	5.6	7.1	8.5	9.4	2.9	5.2	5.1	3.4
Std. Dev.	2.4	3.4	4.7	2.2	2.3	1.5	1.7	2.5	4.3	3.4	5.0	2.9	2.5	0.6	1.5	1.2	2.4	6.3	2.8	6.2	1.2	2.2	4.3	3.4	1.1	1.9	2.2	2.1
														In Percentages														
A	--	--	--	--	15	15	18	--	29	33	40	--	19	9	5	--	21	26	23	--	10	10	9	--	4	8	5	--
B	--	--	--	--	13	12	22	24	34	29	30	21	24	9	7	11	12	25	20	15	12	14	14	16	5	11	7	14
C	--	--	--	--	20	14	17	16	43	36	30	20	9	9	7	3	16	15	18	46	11	19	13	12	4	6	15	4
D	--	--	--	--	14	12	15	10	36	28	30	17	12	6	8	5	19	33	15	44	16	10	26	9	3	11	9	12
E	--	--	--	--	17	17	22	23	44	38	35	35	15	10	4	6	14	22	21	20	5	9	9	13	5	2	9	4
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G	--	--	--	--	15	12	16	22	42	38	27	24	16	10	8	8	15	10	13	22	11	20	32	19	2	9	4	4
H	--	--	--	--	13	8	13	20	39	44	47	18	18	9	10	9	15	15	15	28	10	12	10	20	6	12	6	6
I	--	--	--	--	7	8	13	19	54	53	51	19	17	10	10	6	7	9	5	16	8	8	11	32	7	13	11	8
J	--	--	--	--	11	13	18	28	41	30	36	16	13	9	7	6	19	19	17	30	10	20	13	17	7	9	9	4
K	--	--	--	--	7	12	15	20	28	35	21	27	21	8	15	7	23	19	22	28	13	11	13	15	8	15	13	2
Avg.	--	--	--	--	13.2	12.3	16.9	20.2	39.0	36.4	34.7	21.9	16.4	8.9	8.1	6.7	16.1	19.3	16.9	27.7	10.6	13.3	15.0	17.0	5.1	9.6	8.8	6.4
Std. Dev.	--	--	--	--	3.9	2.7	3.0	4.5	7.2	4.7	7.7	3.2	5.6	1.1	2.9	2.1	1.4	2.3	1.6	3.2	8.8	4.4	7.3	5.9	1.8	3.5	3.3	3.7

(1) If the "representative curriculum" remains representative over the period of graduate study of first-year students enrolled in 1964-65.

(2) If 1964-65 costs per credit hour remain constant over the period of graduate study of first-year students of 1964-65.

(3) If the incomes underlying the opportunity cost estimates remain constant over the period of graduate study of first-year students of 1964-65.

Although it is not very likely that all of the above conditions will hold, these estimates provide new information about the total resource requirements for graduate education, and about the relative input costs which apply to four diverse doctoral programs.

A brief comment on the method of allocating graduate faculty salaries will also help to clarify the general procedure followed in the study. A graduate faculty member is defined as any member of a department engaged in the teaching of graduate courses and/or the supervision of graduate students. Since most university departments do not employ separate graduate faculties, i.e., many graduate faculty members are engaged in undergraduate as well as in graduate instruction, in addition to a variety of other activities, only portions of salaries payed to graduate faculty members were included in the estimates. These are the portions of graduate faculty salaries that compensate time devoted to graduate instruction, graduate student supervision, research, and administration. On the average, the included portion ranged from 66% to 80% of total graduate faculty salaries. The excluded portion of graduate faculty salaries is that which compensates undergraduate teaching and other professional activities. In this study graduate faculty salaries are allocated among the respective activities in accordance with time distribution data obtained by means of a questionnaire designed and distributed specifically for this study. (See the Appendix.)

In this study the total cost of Ph.D.'s is apportioned between the course-taking phase and the research phase of graduate study. The direct costs of the research phase are analyzed in the next chapter. The direct costs of the course-taking phase consist of graduate faculty instructional cost and classroom space costs, while the same set of indirect costs applies to both phases of graduate study. The direct costs of both phases and the indirect or supplemental costs are presented in Table 3, and in Tables 18 and 19 included in the Appendix.

The data gathered for the computation of the presented estimates encompass the entire graduate program of each department, i.e., all courses described as graduate courses in the college catalogs, irrespective of who is enrolled in these courses. Thus the underlying data include credit hours produced for Master degree as well as for Ph.D. degree candidates and also the credit hours

TABLE 3

COST OF TRAINING Ph.D.'S

Universities	Number of Course Credit Hours (1)	Direct Cost of Course-Taking Phase (2)	Number of Research Credit Hours (3)	Direct Cost of Research Phase (4)	Number of Total Credit Hours (5)	Total Supplemental Cost (6)	Total Yearly Expenditure per Student (7)	Y_{ac} = Average Total Cost of a Ph.D. (8)	Opportunity Cost (9)	Opportunity Cost Added to Y_{ac} (10)	% of Y_{ac} That is Faculty Salary (11)	% of Y_{ac} That is Direct Research Cost (12)
						Physics						
A	53.5	$1,113	38.8	$29,876	92.3	$10,061	$6,496	$41,050	$22,392	$63,442	27.7	50.0
B	52.3	889	31.1	23,356	83.4	7,923	8,810	32,168	25,657	57,825	17.8	60.4
C	43.0	848	14.8	8,717	57.8	4,740	3,854	14,305	24,724	39,029	40.3	30.0
D	51.2	1,112	16.7	39,562	67.9	5,569	7,442	46,243	25,191	71,434	28.6	62.4
E	79.5	1,298	34.7	77,589	114.2	5,482	8,944	84,369	27,057	111,426	19.2	74.8
F	61.8	471	81.8	22,004	143.6	7,036	3,684	29,511	30,789	60,300	31.9	46.1
G	54.0	703	37.4	22,216	91.4	6,672	4,980	29,591	24,258	53,849	28.8	28.6
H	48.0	655	26.7	27,821	74.7	12,176	7,850	40,652	27,057	67,709	12.3	38.3
I	46.7	571	33.3	22,877	80.0	10,880	5,614	34,322	33,588	67,910	33.5	8.6
J	61.8	899	11.4	10,659	73.2	4,026	4,117	15,584	26,590	42,147	27.0	29.8
K	47.2	548	64.6	28,424	111.8	9,503	4,886	38,475	27,990	66,465	17.5	36.6
Avg.	54.4	$ 835	35.6	$28,464	90.0	$ 7,700	$6,061	$36,934	$26,845	$63,776	25.9%	42.3%
Wt. Avg.*		$ 730		$26,106		$ 7,788	$5,450	$34,623				
% of Total		2.3%		77.1%		20.9%						
						Zoology						
A	65.5	$1,262	44.4	$33,211	109.9	$ 8,132	$5,321	$42,605	$14,575	$57,180	44.1	39.9
B	56.5	4,874	42.2	33,084	98.7	29,906	5,943	67,864	12,816	80,680	32.2	32.5
C	52.2	645	29.5	21,151	81.7	4,304	6,770	26,126	13,821	39,947	55.3	32.9
D	60.3	672	23.2	16,542	83.6	4,849	4,125	22,063	18,596	40,659	52.4	28.5
E	84.5	722	43.4	33,244	127.9	3,070	4,404	37,036	14,827	51,863	60.6	32.4
F	71.4	744	67.6	11,627	138.9	5,695	4,296	18,066	16,586	34,652	48.9	26.9
G	68.2	321	38.0	16,720	106.2	2,761	5,516	19,802	14,073	33,875	42.6	21.2
H	40.3	591	48.2	37,114	88.5	12,125	8,123	49,830	12,565	62,395	24.1	31.2
I	41.9	773	39.9	21,985	81.8	13,497	8,949	36,255	16,837	53,092	27.0	3.3
J	68.5	2,345	14.0	8,260	82.5	12,623	3,968	23,228	13,570	36,798	42.5	10.2
K	63.3	586	65.0	10,205	128.3	3,987	4,680	14,768	15,581	30,349	33.2	23.0
Avg.	61.1	$1,221	41.4	$22,103	102.5	$ 9,177	$5,645	$32,511	$14,895	$47,408	42.1%	25.6%
Wt. Avg.*		$1,178		$21,942		$ 8,811	$5,587	$31,931				
% of Total		3.8%		68.0%		28.2%						

*Average weighted by number of graduate students enrolled.

TABLE 3 (Concluded)

Universities	Number of Course Credit Hours (1)	Direct Cost of Course-Taking Phase (2)	Number of Research Credit Hours (3)	Direct Cost of Research Phase (4)	Number of Total Credit Hours (5)	Total Supplemental Cost (6)	Total Yearly Expenditure per Student (7)	Y_{ac} = Average Total Cost of a Ph.D. (8)	Opportunity Cost (9)	Opportunity Cost Added to Y_{ac} (10)	% of Y_{ac} That is Faculty Salary (11)	% of Y_{ac} That is Direct Research Cost (12)
						Sociology						
A	63.1	$1,247	23.3	$13,211	86.4	$ 5,270	$ 4,365	$19,728	$22,055	$41,783	56.2	21.0
B	70.5	3,151	20.8	15,537	91.3	10,865	5,660	29,553	22,955	52,508	63.3	6.2
C	73.0	687	7.7	4,897	80.7	2,017	4,460	7,601	29,256	36,857	68.8	9.1
D	56.3	404	18.6	3,664	74.9	2,621	3,920	6,689	25,206	31,895	61.5	11.2
E	86.0	531	25.5	20,935	111.5	1,226	3,340	22,692	28,356	51,048	75.2	20.3
F	67.0	1,248	34.1	13,674	101.1	3,134	3,879	18,056	29,256	47,312	71.3	10.7
G	64.9	622	36.7	14,680	101.6	4,263	4,584	19,565	27,006	46,571	45.5	19.2
H	64.7	1,640	25.1	9,061	89.8	6,100	12,801	16,801	25,656	42,457	43.5	6.5
I	56.5	1,586	8.7	12,684	65.2	9,338	5,731	23,608	44,560	68,168	24.0	1.8
J	74.8	604	8.6	2,528	83.4	1,418	2,246	4,550	24,305	28,855	38.3	18.9
K	64.1	471	34.0	3,026	98.1	3,332	2,519	6,829	27,456	34,285	39.5	1.1
Avg.	67.3	$1,108	22.1	$10,349	89.4	$ 4,508	$ 4,864	$15,970	$27,823	$43,793	53.4%	11.5%
Wt. Avg.*		$ 923		$ 9,777		$ 4,364	$ 4,184	$15,114				
% of Total		6.9%		64.7%		28.2%						
						English						
A	64.8	$ 794	29.1	$ 1,397	93.8	$ 2,064	$ 2,134	$ 4,255	$23,635	$27,890	65.8	2.7
B	56.1	1,178	41.4	3,064	97.5	7,313	2,399	11,555	19,573	31,128	42.5	2.5
C	71.0	506	7.2	4,478	78.2	1,642	3,019	6,626	21,789	28,415	64.5	14.9
D	61.0	410	14.2	5,723	75.2	1,955	2,626	8,088	21,419	29,507	66.6	13.4
E	97.8	1,359	29.4	6,350	127.1	8,643	1,000	16,352	23,266	39,618	37.2	14.5
F	72.9	1,541	40.3	6,045	113.2	5,094	1,693	12,680	27,697	40,377	69.2	0.9
G	61.6	497	29.0	18,966	90.6	2,537	2,500	22,000	21,789	43,789	48.8	18.7
H	55.8	1,338	14.7	4,204	70.5	6,134	3,383	11,676	16,988	28,664	37.0	8.8
I	57.1	1,177	5.6	1,680	62.7	5,899	5,183	8,756	39,515	48,271	38.8	1.4
J	75.5	1,897	12.7	2,202	88.2	3,881	1,027	7,980	18,465	26,445	47.1	12.9
K	48.6	669	46.4	8,398	95.0	3,040	2,146	12,107	23,266	35,373	46.2	14.0
Avg.	65.6	$1,033	24.5	$ 5,682	90.1	$ 4,382	$ 3,283	$11,098	$23,400	$34,498	51.2%	9.4%
Wt. Avg.*		$1,202		$ 5,768		$ 5,054	$ 3,930	$12,025				
% of Total		9.3%		51.2%		39.5%						

*Average weighted by number of graduate students enrolled.

earned by undergraduates and by extradepartmental graduate students enrolled in a given department's graduate courses.* The generally encountered interrelatedness between graduate and undergraduate programs and the fact that the training of Ph.D. candidates is rarely confined to courses within the degree-granting department, suggests that the cost analysis should be based on credit hour production of all courses designated as graduate courses by the departments in question. The curriculum analysis also indicates that to varying degrees the typical Ph.D. recipient of a given department earns graduate credit hours in other departments. The Y_{ac} estimates are based on the assumption that graduate credit hours earned in other departments are equally costly as those earned in the degree-granting department.

This broad interpretation of graduate credit hours produced is capable of generating two types of distortions. It can produce a relatively low cost per graduate credit hour in one department which has more masters' candidates but the same number of Ph.D. candidates as other departments. Also it can produce a low cost per graduate credit hour in a department which exports more graduate credit hours (i.e., produces graduate credit hours for graduate students from other departments and/or for undergraduates) relative to other departments with an equal number of Ph.D. candidates. In view of the paucity of data on imported and exported credit hours of departments, and on the breakdown in graduate enrollments between terminal masters' candidates and potential Ph.D. candidates, possible distortions such as the above cannot be identified, and if they do exist their magnitude cannot be determined.

Some comments are in order on the general availability of data required for the cost estimates. Various aspects of the needed information were either totally unavailable or found to be in a different than the desired form or in insufficient detail at selected institutions. The following include the major deficiencies encountered:

(1) Enrollment data in general lack the desired detail. Frequently graduates and undergraduates are not itemized separately in records on student enrollment in individual courses. The registration of graduate students after fulfillment of all credit hours or residence requirements was at times found to be inadequate or nonexistent. Also the recording of full-time versus part-time enrollment was often found to be inaccurate or lacking.

(2) Lack of uniformity in the conferment of thesis and research credit hours earned by graduate students. In some instances research credit hours had to be imputed from semesters of graduate thesis residence.

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*In instances where undergraduates were given undergraduate credits upon completion of graduate courses, such credit hours were included in the cost analysis as graduate student credit hours produced.

(3) Uneven quality of records on years of graduate student residence, fellowships earned, and graduate student appointments and earnings.

(4) Information on the number of graduate students supervised by each faculty member (Master degree candidates, Ph.D. candidates, chairmanship or participating membership of graduate committees, etc.) would have been helpful but is scarcely available.

(5) Not all but most institutions made available space surveys they had conducted and supplied data on space utilization.

(6) Faculty time distribution questionnaires were not distributed in one institution which was engaged in a similar survey for internal purposes at the time of the site visit and it was felt that simultaneous distribution of two questionnaires would seriously limit the number of responses to both surveys. The data compiled by this particular university for internal purposes was made available to us, but unfortunately it was not comparable to the data compiled with our own questionnaire. The chairman of one department in one other university discouraged distribution of the questionnaire, and one additional department failed to return the distributed time distribution forms. In the above cases the faculty time distributions were inputed either from data collected within the institution or from averages of the other departments in the same discipline.

(7) One university in the sample denied access to the sponsored research budgets and in two or three other universities there were problems of retrieving all the required research budgets. In the former case sponsored research funds had to be imputed from the average of all other included departments of the same discipline. In the latter cases an attempt was made to estimate as accurately as possible the total 1964-1965 research expenditures of departments with the use of financial reports and other supporting data.

In summary, it is felt that data deficiencies have somewhat limited the accuracy of the estimates, but have not ruled out the possibility of making reasonably accurate estimates. To compensate for data deficiencies in the best possible way much effort was put into careful imputation of values for all variables that could not be directly measured. With continued improvement in the data recording and data processing methods employed by institutional research personnel of universities, it should be possible to improve the accuracy of above estimates in the near future. For the time being the estimates computed in this study serve chiefly as preliminary bench marks for future comparison.

CHAPTER III

METHOD OF ANALYSIS APPLIED TO THE RESEARCH ASPECT OF GRADUATE EDUCATION

This chapter presents (a) a cost analysis of the research aspect of graduate education, and (b) a method for allocating sponsored research expenditures to graduate education.

A COST ANALYSIS OF THE RESEARCH ASPECT OF GRADUATE EDUCATION

One major factor in doctoral programs and in the total expenditures thereof is the research activity of graduate faculty and of graduate students. In this study the research process is explicitly considered an essential element of graduate training programs, and a part of the cost of research inputs is incorporated into the cost of a Ph.D. The inclusion of research costs with other costs of the Ph.D. is justified on basis of the close relation between research endeavors of faculty and their approach in course and research instruction of graduate students.

The procedures which were developed for estimating the cost of research inputs are based on a rather broad interpretation of the research process in graduate education. Research with respect to graduate faculty is here defined as any activity that is motivated by the search for new knowledge or the advancement of a discipline, as well as any activity that is directed at imparting research skills to graduate students. Thus research activity comprises the actual execution of a research project, as well as the training of students to carry out research. Whenever graduate faculty and graduate students interact in the execution of a research project, these two aspects of research activity are conducted jointly. Moreover, in accordance with the above definition, an English professor who supervises a student's dissertation is engaged in research activity to an equal extent as a Physics professor when conducting experiments in his laboratory.

Analysis of the research aspect of doctoral programs requires some type of a measurement of research conducted by graduate students. Since the approach followed in this study involves cost analysis in terms of credit hours earned by graduate students for the Ph.D. degree, the research phase of a doctoral program was measured on the basis of graduate research credit hours earned. The transcripts of a sample of recent Ph.D. recipients of respective departments were used to define the research phase of each department's doctoral program with respect to the average number of research credit hours earned for the Ph.D. degree. This method of defining the research portion of doctoral programs is not entirely satisfactory since some graduate departments do not credit their students for research executed as part of doctoral training to an equal extent as do other graduate departments. Furthermore, in some universities the rules which determine how many research or thesis credit hours a student may earn and what the student must accomplish in order to earn research credit hours, are applied haphazardly. However, all institutions* included in this study recognized and awarded research credit hours to a certain degree. Therefore, an effort was made (by use of imputation in a few instances) to estimate as accurately as possible the average number of research or thesis credit hours,** comprised by the "representative Ph.D. curriculum" of each department.

The basic procedure used here for calculation of research costs involves determining separately for each department the costs of "producing" a single research credit hour in 1964-65 and multiplying individual research costs by the average number of research credit hours earned by recent doctorates of the department. More specifically, the cost of the research phase involves four major cost elements: (1) allocated sponsored research costs, (2) graduate faculty salaries that compensate research time and graduate student supervision time, (3) research laboratory space costs, and (4) a set of indirect costs such as library, administrative, and departmental supplies, equipment and clerical costs. The sum of these four costs is then multiplied by the average number of research credit hours earned by students of each department, to derive the total cost of the research phase of graduate study.

Further clarification of the nature of some of the above cost elements may be in order. All of the direct costs reflect the dollar value of inputs of research activity. The sponsored research budgets cover expenditures for research inputs, but only a part of the research budgets is allocated as cost of the research phase of graduate study. The allocation method used for this purpose will be described subsequently. Research activity of graduate faculty was defined to include time spent performing research as well as time spent training graduate students to perform research. It follows that the portion of total graduate faculty salaries which compensates research time and graduate student supervision time, represents a cost of research activity. Research laboratory space costs were calculated with respect to standards for research space requirements per graduate student in each discipline,* and a rental rate which is assumed to cover all costs of utilizing a given amount of space. The total analysis of costs of physical facilities will be dealt with in the next chapter. The cost estimates of the research phase of doctoral programs is based on three assumptions:

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*One of the twelve institutions surveyed did not confer research credit hours to graduate students but this university had to be omitted from the study for other reasons as well.

**A research credit hour was taken to be any credit hour defined as a research or thesis credit hour; any credit hour earned in a graduate course described as a research course; and any credit hour earned in a graduate course defined as "independent study."

(1) That only a part of the sponsored research funds of a department is allocable as a cost of graduate training.

(2) That the total cost of research space utilized by graduate students is allocable as a cost of graduate training.

(3) That the total cost of time spent by graduate faculty on research** and on graduate student supervision is allocable as a graduate training cost.

The first assumption will be elaborated in the next section. Although there are grounds on which assumptions (2) and (3) may be challenged, they approximate reasonably well the separation of inputs which are specific to graduate programs, and they provide a useful framework for the calculation of research training cost estimates. The derivation of research cost estimates and the research costs of doctoral programs in the four disciplines, are set forth in summary form in Table 4 and also on Table 19 included in the Appendix.

A METHOD FOR ALLOCATION OF SPONSORED RESEARCH EXPENDITURES TO GRADUATE EDUCATION

The problem of isolating the training component of research expenditures is analogous to the problem of identifying the consumption component of educational costs. Both problems stem from the fact that a large degree of "jointness" characterizes the production of education. Though it is known that most types and levels of education confer upon the student the means to a better life as well as marketable skills and capabilities, it is exceedingly difficult to estimate the so-called consumption element of educational costs. Economists to date have not worked out a solution for the consumption versus

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*Such standards were obtained from Taylor, Lieberfeld, and Heldman, Inc., Report to Association of State Institutions of Higher Education in Colorado, Manual of Procedures and Criteria for Campus Development and Capital Outlay Planning, New York, April, 1964.

**The total cost of graduate faculty time spent on research during the academic year was allocated to the cost of training Ph.D.'s. However, in the sciences the majority of graduate faculty members receive summer salaries for devoting 100% of their time to research during summer months. The cost of graduate faculty summer research time was not added on to the cost of graduate education.

TABLE 4

SUMMARY OF COST OF THE RESEARCH PHASE OF GRADUATE STUDY

Universities	Number of Research Credit Hours in "Representative Curriculum" (1)	Research Credit Hours as % of Total Credit Hours Earned (2)	Cost of Research Phase of Ph.D. (3)	Cost of Research Phase as % of Y_{ac} (4)	% of Y_{ac} That Represents Non-University Subsidy (5)
		Physics			
A	38.8	42	$31,105	83.1	49.7
B	31.1	38	26,310	82.2	65.8
C	14.8	26	9,930	69.4	23.0
D	16.7	25	40,931	88.5	58.5
E	34.7	30	79,254	93.9	74.8
F	81.8	57	26,012	88.1	42.4
G	37.4	41	24,946	84.3	30.0
H	26.7	36	32,173	79.1	53.4
I	33.3	41	27,405	79.8	13.1
J	11.4	16	11,286	72.4	38.3
K	64.6	58	33,915	88.1	44.8
Avg.	35.6	37%	$31,479	82.6%	44.9%
Std. Dev.	21.1	14.5%	$17,511	11.4%	
		Zoology			
A	44.4	40	$36,496	85.6	39.2
B	42.4	43	45,870	67.6	37.6
C	29.5	36	22,714	86.9	30.4
D	23.2	28	17,887	81.1	19.9
E	43.4	34	34,285	92.6	29.2
F	67.6	49	14,398	79.7	30.2
G	38.0	36	17,708	89.4	16.4
H	48.2	55	43,717	87.7	44.4
I	39.9	49	28,568	78.8	--
J	14.0	17	10,402	44.8	--
K	65.0	51	12,220	82.7	28.6
Avg.	41.4	40%	$25,842	79.7%	30.6%
Std. Dev.	23.3	12.2%	$12,087	40.2%	
		Sociology			
A	23.3	27%	$14,632	74.2	25.8
B	20.8	23	18,012	60.9	17.6
C	7.7	10	5,084	66.9	43.5
D	18.6	25	4,315	64.5	21.6
E	25.5	23	21,215	93.5	17.8
F	34.1	34	14,731	81.6	11.4
G	36.7	36	16,221	82.9	23.8
H	25.1	28	10,767	64.1	15.0
I	8.7	13	13,928	59.0	8.0
J	8.6	10	2,674	58.8	25.3
K	34.0	35	4,182	61.2	13.2
Avg.	22.1	24%	$11,433	69.8%	20.3%
Std. Dev.	10.5	8.9%	$ 6,104	45.9%	
		English			
A	29.1	31	$ 2,037	47.9	0.0
B	41.4	42	6,169	53.4	1.6
C	7.2	9	4,629	69.9	2.9
D	14.2	19	6,092	75.3	5.1
E	29.4	23	8,349	51.0	1.5
F	40.3	39	7,858	62.0	0.0
G	29.0	32	19,778	90.0	0.05
H	14.7	17	5,482	46.9	8.7
I	5.6	9	2,206	25.2	2.6
J	12.7	14	2,760	34.6	3.7
K	46.4	49	9,882	81.6	1.4
Avg.	24.5	25.8%	$ 6,840	57.9%	3.0%
Std. Dev.	14.4	13.3%	$ 4,757	49.4%	

the investment problem of education and have also refrained from allocating academic research expenditures between costs of new knowledge and costs of research training.

Jointness of production means that the production of one service entails the production of another. The above does not imply that research can be carried out only in an academic context or that it is inextricably linked with university instruction. However, it is true that training at the graduate level cannot be carried out effectively in the absence of ongoing research and a so-called research atmosphere. This complementarity between the process of research and the process of graduate training is most apparent in research-oriented disciplines, because for a large percentage of Ph.D. recipients in these fields research becomes the major professional activity. Even in the less research-oriented disciplines, however, scholarly investigations are at times carried out jointly between teachers and students; in that sense the search for new knowledge constitutes an integral part of graduate education in general.

When research is conducted within a university department it essentially has two outputs: new knowledge and new skills. Given the complementarity of research and graduate training the question arises as to what portion of research costs should be allocated as costs of training Ph.D.'s. If we could measure the two outputs of research endeavors the cost might be allocated accordingly. However, a satisfactory yardstick for research output has to date not been developed, and the amount of research training derived from given projects does not readily lend itself to measurement.

One method of estimating that part of the total cost of research enterprise which may be allocated to the cost of new skills involves use of graduate faculty time distribution data. On the basis of such data, the sum of the percentages of faculty time spent on research and on graduate student supervision was taken to represent total faculty involvement in research activity. The following ratio was derived separately from each department's graduate faculty data in order to apportion sponsored research funds between the cost of new skills and the cost of new knowledge:

$$\frac{R_t}{R_p + R_t} \quad \text{or} \quad \frac{R_t}{R_a}$$

where

R_p = research performance = % of faculty time spent on research

R_t = research training = % of faculty time spent on graduate student supervision

R_a = total research activity = $R_p + R_t$

On the assumption that products of research performance and research training are equally costly per unit of time, this ratio provides an objective cost estimate of the training aspect of sponsored research.

When this method is applied to the faculty time distribution data gathered for this study the allocation ratio for each department is less than one-half. With regard to disciplines, the average percentages of total departmental sponsored research expenditures which may be allocated as training costs of Ph.D.'s are 30% in Physics, 20% in Zoology, and 20% in Sociology. Research budgets do not enter the cost of the research phase of graduate study in English, as English departments have few research funds to be allocated.

Clearly this allocation method has its shortcomings as well as its advantages. The fact that research and research training are jointly produced in the university setting and the fact that the output of research and research training is extremely difficult to measure limits the possibility of testing the assumption that products of research performance and research training are equally costly per unit of time. This points to a shortcoming of the allocation method. In its favor one might point to its empirical basis, i.e., it is based on actual graduate faculty time distribution data. Also it may be noted that the above method lends itself to modification and supplementation. For example, if data could be gathered on the extent to which graduate students are involved in research projects it might be possible to develop a more refined approach based on the research effort of graduate students as well as that of graduate faculty. Moreover, this type of an allocation approach may also prove to be of value to the solution of other allocation problems in the economics of higher education.

The distribution of the total costs of a Ph.D. between costs of the research phase and costs of the course-taking phase, as shown on Figure 1, indicates that the cost of the research phase is usually several times as large as the cost of the course-taking phase, even though course credit hours outnumber research credit hours earned by the typical doctorate holder of almost every department. In each of the four disciplines the research cost represents a substantial portion of the total cost of a Ph.D. The research cost as an average percentage of Y_{ac} (average total cost of a Ph.D.) varies between disciplines and is lowest for English. This follows from a previously noted fact that few English departments have research funds. The ranges for total research costs and for research cost as a percentage of Y_{ac} are very wide and show considerable overlap between disciplines. Variability in the research cost of a Ph.D. within any one discipline is considered to be a result of similar factors as those which make for variability in the total cost estimates of Ph.D.'s. These factors will be discussed in a later chapter on findings and data analysis.

Relevant to the costs of the research phase of doctoral programs is a series of estimates which represent the percentage of Y_{ac} that constitutes nonuniversity subsidies of the cost of a Ph.D., or that part of Y_{ac} which is

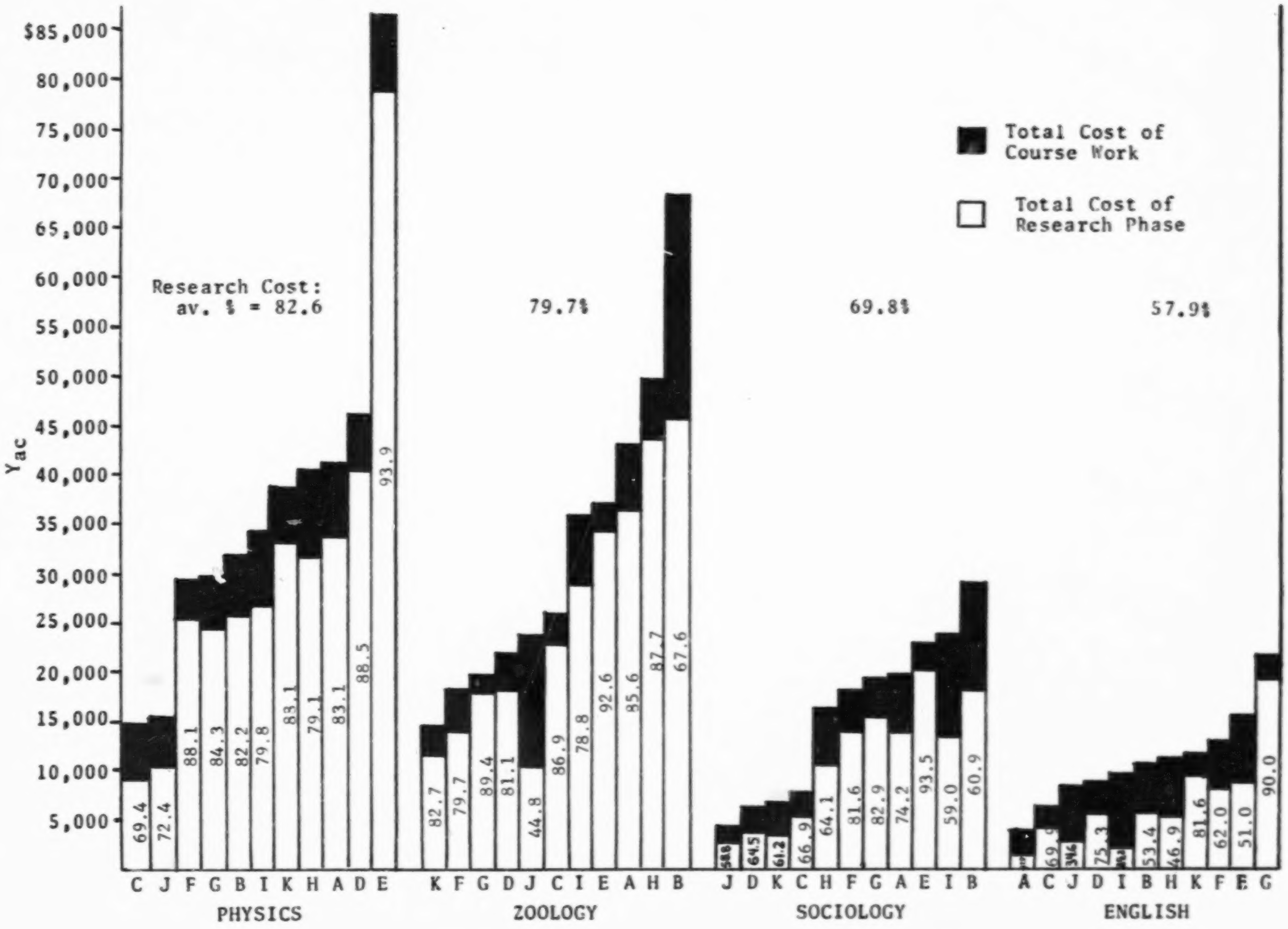

Figure 1. Distribution of Y_{ac} between research and non-research costs on a percentage basis.

payed for out of nonuniversity funds. These estimates are presented in column 5 of Table 4 and are composed entirely of allocated sponsored research funds and fellowship funds, while they exclude such funds as universities obtain for building purposes from outside sources. This exclusion does not appear to seriously bias the estimates, as the estimated cost of physical facilities accounts for a relatively small portion of the Y_{ac}'s (see next chapter). In instances where university construction is subsidized, the subsidy is likely to cover only a small part of the space utilization costs of a particular graduate program. Column 5 of Table 4 shows that the nonuniversity subsidies as a percentage of Y_{ac} range from an average of 44.9% in Physics to an average of 3% in English, while the percentages also show considerable variability within any one discipline.

In this chapter an attempt has been made to delineate the research phase of doctoral programs and to estimate its cost as a component of the total cost of training Ph.D.'s. Presumably the research activity of graduate faculty and graduate students, which constitutes the research phase of doctoral programs, bears a qualitative relationship to respective doctoral programs. Such relationships can be further explored in the light of available indices of quality in graduate education. The federal government supports graduate education primarily via the subsidization of research. Thus it may be particularly this aspect of the cost estimates of training Ph.D.'s that has the potential of providing insight on policy objectives, which govern the distribution of federal aid to graduate education.

CHAPTER IV

METHOD OF ANALYSIS APPLIED TO OPPORTUNITY COSTS, PHYSICAL FACILITIES COSTS AND SUPPLEMENTAL COSTS

In this chapter the estimation of three types of cost elements that enter into the total cost of Ph.D.'s will be described in greater detail: opportunity costs, costs of utilizing physical facilities, and the indirect or supplemental cost elements.

ESTIMATION OF STUDENTS' INCOME FOREGONE

When viewing graduate education as a form of human capital formation one generally classifies the students along with other productive inputs. Those who eventually embody the human capital of a society also contribute to its formation at an earlier stage. The time and effort supplied by students are as essential as any other inputs that enter into the production of Ph.D.'s. Thus economists have in recent years developed the point of view that students are "self-employed" producers of capital* or "producers engaged in the production of knowledge in their own minds."** It follows that whenever employment constitutes an actual alternative to schooling, thus confronting the student with a choice between earning and learning the opportunity cost of learning must be added on to the other costs of education. It is evident that the alternatives of earning and learning become mutually exclusive only under exceptional circumstances. To varying degrees learning is inherent in most employment situations, whereas there are also many opportunities for realizing earnings in conjunction with schooling, particularly in the context of graduate education. Nevertheless, the data indicate that in most instances earnings of graduate students fall short of their earnings potential in alternative, full-time employment situations. Thus it becomes one of the tasks of this study to estimate opportunity costs with respect to the net difference between students' foregone income and actually realized income during the entire period of graduate study.

Earnings foregone by graduate students were measured in the following way. First a weighted average annual income for bachelor degree holders was derived for the period of graduate study from 1964 cross sectional National Register Salary Data, and was adjusted to an academic year base. Then the weighted average annual income for each discipline was multiplied by the adjusted average number of years spent on the doctorate in each department to derive the gross opportunity cost of a Ph.D. in each department. The total number of years spent on the average in obtaining the doctorate in each department was corrected for years of full-time employment away from school, during the period of graduate study, to derive adjusted average number of years spent on the Ph.D. Information gathered on graduate students suggests that students who accept full-time employment away from school before completing the Ph.D. may be earning salaries which are on par with their earnings potential. The adjusted average number of years spent on the doctorate in each department was multiplied by average academic year earnings of graduate students in respective disciplines. Subtracting total earnings realized during graduate study from the gross opportunity cost yields the net opportunity cost of the Ph.D. In the absence of satisfactory records on both employment patterns of graduate students during summers and on graduate student summer earnings it was felt that the opportunity cost of a Ph.D. should be based on academic-year income differentials rather than on calendar-year income differentials.

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*T. W. Schultz, "Capital Formation by Education," Journal of Political Economy, December, 1960, p. 573.

**Frits Machlup, Production and Distribution of Knowledge in the United States, Princeton University Press, 1962, p. 386.

Full-time employment coincident with completion of the doctorate, is more characteristic of the pattern of graduate study in Sociology and English than in Physics and Zoology. In Physics there was only one of eleven departments that had a sizable number of students accepting full-time jobs before completion of the doctorate, whereas in practically all of the English departments which were surveyed for this study, the majority of students accepted full-time employment for one or more years before receipt of the Ph.D. degree.

The estimates presented on Table 5 indicate that the total opportunity cost of a Ph.D. is substantial and that it represents an average of:*

$26,845 = 42% of the total social cost of a Ph.D. in Physics

$14,895 = 31% of the total social cost of a Ph.D. in Zoology

$27,823 = 63% of the total social cost of a Ph.D. in Sociology

$23,400 = 68% of the total social cost of a Ph.D. in English

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*Schultz presented estimates of earnings foregone by students at the level of college and university education. According to Schultz's estimates, incomes foregone represent 60% of the total cost in 1950 and 59% in 1956. T. W. Schultz, "Capital Formation by Education," Journal of Political Economy, December, 1960, p. 577.

TABLE 5

OPPORTUNITY COSTS

Universities	Average Number of Years Spent Obtaining Ph.D. (1)	Column 1 Adjusted for Number of Years in Absentia (i.e., full time employment) (2)	Average Annual Income of Bachelor Degree Holders* (3)	Gross Opportunity Costs (4)	Adjusted Number of Years Spent on Ph.D. (by years in absentia) (5)	Average Income per Graduate Student per Year (6)	Total Income Earned by Graduate Student (7)	Net Opportunity Cost (column 4-7) (8)	Opportunity Cost Added to Y_{ac} (9)
Physics									
A	4.8	4.8	$7,000	$33,600	4.8	$2,335	$11,208	$22,392	$63,442
B	5.5	5.5	7,000	38,500	5.5	2,335	12,843	25,657	57,825
C	7.3	5.3	7,000	37,100	5.3	2,335	12,376	24,724	39,029
D	5.5	5.4	7,000	37,800	5.4	2,335	12,609	25,191	71,434
E	5.8	5.8	7,000	40,600	5.8	2,335	13,543	27,057	111,426
F	6.6	6.6	7,000	46,200	6.6	2,335	15,411	30,789	60,300
G	5.2	5.2	7,000	36,400	5.2	2,335	12,142	24,258	53,849
H	5.8	5.8	7,000	40,600	5.8	2,335	13,543	27,057	67,709
I	7.2	7.2	7,000	50,400	7.2	2,335	16,812	33,588	67,910
J	5.9	5.7	7,000	39,900	5.7	2,335	13,310	26,590	42,147
K	6.0	6.0	7,000	42,000	6.0	2,335	14,010	27,990	66,465
Avg.	5.9	5.7	$7,000	$40,280	5.7	$2,335	$13,430	$26,845	$63,776
Zoology									
A	6.0	5.8	$4,700	$27,260	5.8	$2,187	$12,685	$14,575	$57,180
B	6.1	5.1	4,700	23,970	5.1	2,187	11,154	12,816	80,680
C	6.1	5.5	4,700	25,850	5.5	2,187	12,029	13,821	39,947
D	7.4	7.4	4,700	34,780	7.4	2,187	16,184	18,596	40,659
E	6.3	5.9	4,700	27,730	5.9	2,187	12,903	14,827	51,863
F	6.6	6.6	4,700	31,020	6.6	2,187	14,434	16,586	34,652
G	7.4	5.6	4,700	26,320	5.6	2,187	12,247	14,073	33,875
H	7.9	5.0	4,700	23,500	5.0	2,187	10,935	12,565	62,395
I	6.7	6.7	4,700	31,490	6.7	2,187	14,653	16,837	53,092
J	6.6	5.4	4,700	25,380	5.4	2,187	11,810	13,570	36,798
K	6.6	6.2	4,700	29,14C	6.2	2,187	13,559	15,581	30,349
Avg.	6.7	5.9	$4,700	$27,858	5.9	$2,187	$12,963	$14,895	$47,408
Sociology									
A	5.3	4.9	$6,600	$32,340	4.9	$2,099	$10,285	$22,055	$41,783
B	9.5	5.1	6,600	33,660	5.1	2,099	10,705	22,955	52,508
C	8.4	6.5	6,600	42,900	6.5	2,099	13,644	29,256	36,857
D	6.5	5.6	6,600	36,960	5.6	2,099	11,754	25,206	31,895
E	6.6	6.3	6,600	41,580	6.3	2,099	13,224	28,356	51,048
F	7.0	6.5	6,600	42,900	6.5	2,099	13,644	29,256	47,312
G	6.3	6.0	6,600	39,600	6.0	2,099	12,594	27,006	46,571
H	7.5	5.7	6,600	37,620	5.7	2,099	11,964	25,656	42,457
I	9.9	9.9	6,600	65,340	9.9	2,099	20,780	44,560	68,168
J	7.7	5.4	6,600	35,640	5.4	2,099	11,335	24,305	28,855
K	6.2	6.1	6,600	40,260	6.1	2,099	12,804	27,456	34,289
Avg.	7.4	6.1	$6,600	$40,800	6.1	$2,099	$12,977	$27,823	$43,793
English									
A	7.4	6.4	$5,900	$37,760	6.4	$2,207	$14,125	$23,635	$27,890
B	7.9	5.3	5,900	31,270	5.3	2,207	11,697	19,573	31,128
C	8.5	5.9	5,900	34,810	5.9	2,207	13,021	21,789	28,415
D	8.5	5.8	5,900	34,220	5.8	2,207	12,801	21,419	29,507
E	8.7	6.3	5,900	37,170	6.3	2,207	13,904	23,266	39,618
F	7.6	7.5	5,900	44,250	7.5	2,207	16,553	27,697	40,377
G	7.7	5.9	5,900	34,810	5.9	2,207	13,021	21,789	43,789
H	6.8	4.6	5,900	27,140	4.6	2,207	10,152	16,988	28,664
I	10.7	10.7	5,900	63,130	10.7	2,207	23,615	39,515	48,271
J	8.8	5.0	5,900	29,500	5.0	2,207	11,035	18,465	26,445
K	8.7	6.3	5,900	37,170	6.3	2,207	13,904	23,266	35,373
Avg.	8.3	6.3	$5,900	$37,384	6.3	$2,207	$13,984	$23,400	$34,498

*Source: 1964 National Register.

These estimates constitute a measure of the difference between the student's earning power when fully employed and the earnings he realizes as a student, combined with the modified number of years spent obtaining the doctorate. In interpreting or using the above estimates of opportunity costs of a Ph.D. one should be aware of the following conditions on which the estimates are based:

(1) That Bachelor degree holders who are enrolled in graduate schools can actually find employment at the stipulated salaries.

(2) That all graduate students have the opportunity to earn average, academic-year graduate students' incomes.

(3) That graduate students' earnings during years of full-time employment away from school are such that no income is foregone during those years.

(4) That graduate students typically realize summer earnings roughly proportional to 2/12 of Bachelor degree holders' calendar year salaries.

For the last of these four conditions supporting evidence is almost totally lacking. If most graduate students in fact continue their studies during summers and thus forego earnings, the opportunity cost estimates have a downward bias. However, if in the future more information on summer activities and summer earnings of graduate students becomes obtainable, and if the new information does not support condition (4), the opportunity cost estimates can readily be adjusted.

ESTIMATION OF THE COST OF PHYSICAL FACILITIES

Three different types of physical facilities were analyzed and included with other inputs of Ph.D. programs: classroom space, student research laboratory or office space, and faculty office space. Estimates of the cost of physical facilities were derived with the following two steps:

(1) Determination of amount of space required per graduate student course credit hour, per graduate student engaged in research, and per graduate faculty member in terms of square footage.

(2) Determination of annual costs of utilizing a given amount of space.

The main problem of this part of the analysis is to ascertain the cost of utilizing various sections of space scattered over one or several different buildings. It is rarely found that graduate programs at any time utilize a building in its entirety, and the total amount of space used by the graduate program of a department is rarely located in one single building. It is extremely difficult if not impossible to determine from university records the capital value of a part of a building and the annual cost of utilizing a certain section of a building. Also universities in their accounting procedures do not allow for depreciation as a part of current costs of plant and equipment. For the above reasons an alternative method of estimating costs of physical facilities was chosen and based on the use of rental rates. Rental rates are assumed to include the annual return on capital value as well as the cost of operating and maintaining a given amount of space. A rental rate, indicative of the yearly price per square foot, either payed or charged by the university for rented facilities, was obtained for each institution in the sample.

Workable floor area standards for the various types of facilities used by graduate programs in four disciplines were adopted from Manual of Procedures and Criteria for Campus Development and Capital Outlay Planning, Taylor, Lieberfeld, and Heldman, Inc.* Use of the Colorado space standards rather than the actual amounts of space utilized for the various functions of individual graduate programs was suggested by two factors: (1) Calculating space requirements in the light of certain standards appeared to lend more validity to the estimates than the measurement of actual though often temporary and inadequate physical facilities; (2) the standards of the "Colorado Space Manual" roughly corresponded to some of the targets expressed in space studies undertaken by a number of the participating institutions.

The "Colorado Space Manual" presents optimal square footage per student station for a range of class sizes. The weighted average size of a student classroom station was calculated for each institution on the basis of optimal square footage and the percentage distribution of class sizes found in the graduate programs during 1964-65. The size of a student station represents the amount of space required for one class contact hour and student station standards were combined with the space utilization rate and the rental rate applicable to each individual university for the estimation of cost of classroom space per graduate student credit hour. Table 6 presents the estimates for the four disciplines and also illustrates the calculations with which the estimates were derived.

The size of optimal research facilities for graduate students in Physics and Zoology was derived from standards in the "Colorado Space Manual" for research stations for Faculty and Professionals, i.e., 110 square feet per graduate student in these two disciplines. For the requirement of research and individual study space per graduate student in Sociology and English

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*From Report to Association of State Institutions of Higher Education In Colorado, Manual of Procedures and Criteria For Campus Development and Capital Outlay Planning, Taylor, Lieberfeld, and Heldman, Inc., New York, April, 1964.

TABLE 6

NON-RESEARCH (CLASSROOM) SPACE COST PER GRADUATE STUDENT CREDIT HOUR PRODUCED

Universities	Weighted Average Size of Student Station in Ft^2	Yearly Rental Rate (dollars per ft^2 per year)	Yearly Rental Cost of a Student Station	Proportion of a Calendar Year Represented by an Academic Year	Rental (Space) Cost per Student Station per Academic Year	Number of Credit Hours a Station can Produce in a Term (based on classroom utilization rate)	Number of Terms in an Academic Year	Number of Graduate Student Non-Research Credit Hours a Station can Produce in an Academic Year	Space (Rental) Cost per Student Station per Graduate Student Credit Hour Produced	Space (Rental) Cost per Student Station per Semester Hour Produced
					Physics					
A	16.4	$2.75	$45.10	.67	$30.21	30	2	60	$.50	$.50
B	16.8	1.25	21.00	.75	15.75	29.5	2	59	.27	.27
C	16.0	5.00	80.00	.75	60.00	32	2	64	.94	.94
D	15.8	4.25	67.15	.75	50.36	28	2	56	.90	.90
E	15.7	2.81	44.11	.75	33.08	26	2	52	.64	.64
F	16.1	2.25	36.22	.75	27.16	32	2	64	.42	.42
G	14.6	4.00	58.40	.75	43.80	38	3	114	.38	.57
H	15.7	5.40	84.78	.75	63.58	35	3	105	.60	.90
I	15.8	4.00	63.20	.75	47.40	28	3	84	.56	.84
J	15.5	3.36	52.08	.75	39.06	35	3	105	.37	.55
K	16.1	4.00	64.40	.75	48.30	27	3	81	.59	.88
					Zoology					
A	16.4	$2.75	$45.10	.67	$30.21	30	2	60	$.50	$.50
B	16.8	1.25	21.00	.75	15.75	29.5	2	59	.27	.27
C	16.0	5.00	80.00	.75	60.00	32	2	64	.94	.94
D	15.8	4.25	67.15	.75	50.36	28	2	56	.90	.90
E	15.7	2.81	44.11	.75	33.08	26	2	52	.64	.64
F	16.1	2.25	36.22	.75	27.16	32	2	64	.42	.42
G	14.6	4.00	58.40	.75	43.80	38	3	114	.38	.57
H	15.7	5.40	84.78	.75	20.14	35	3	105	.60	.90
I	15.8	2.90	45.82	.75	34.36	28	3	84	.40	.60
J	15.5	3.36	52.08	.75	39.06	35	3	105	.37	.55
K	16.1	4.00	64.40	.75	48.30	27	3	81	.59	.88
					Sociology					
A	16.4	$2.75	$45.10	.67	$30.21	30	2	60	$.50	$.50
B	16.8	1.25	21.00	.75	15.75	29.5	2	59	.27	.27
C	16.0	5.00	80.00	.75	60.00	32	2	64	.94	.94
D	15.8	4.25	67.15	.75	50.36	28	2	56	.90	.90
E	15.7	2.81	44.11	.75	33.08	26	2	52	.64	.64
F	16.1	2.25	36.22	.75	27.16	32	2	64	.42	.42
G	14.6	4.00	58.40	.75	43.80	38	3	114	.38	.57
H	15.7	5.40	84.78	.75	63.58	35	3	105	.60	.90
I	15.8	1.70	26.86	.75	20.14	28	3	84	.24	.36
J	15.5	3.36	52.08	.75	39.06	35	3	105	.37	.55
K	16.1	4.00	64.40	.75	48.30	27	3	81	.59	.88
					English					
A	16.4	$2.75	$45.10	.67	$30.21	30	2	60	$.50	$.50
B	16.8	1.25	21.00	.75	15.75	29.5	2	59	.27	.27
C	16.0	5.00	80.00	.75	60.00	32	2	64	.94	.94
D	15.8	4.25	67.15	.75	50.36	28	2	56	.90	.90
E	15.7	2.81	44.11	.75	33.08	26	2	52	.64	.64
F	16.1	2.25	36.22	.75	27.16	32	2	64	.42	.42
G	14.6	4.00	58.40	.75	43.80	38	3	114	.38	.57
H	15.7	5.40	84.78	.75	63.58	35	3	105	.60	.90
I	15.8	1.75	27.65	.75	20.73	28	3	84	.25	.37
J	15.5	3.36	52.08	.75	39.06	35	3	105	.37	.55
K	16.1	4.00	64.40	.75	48.30	27	3	81	.59	.88

a criterion developed for multiple occupancy office stations for teaching assistants and research assistants was adopted from the above Manual. In accordance with this standard 50 square feet are allocated to the office station for a graduate student in Sociology and English. The allowance of research space per graduate student is based on the assumption that one student station is fully utilized by a single graduate student during three-fourths of a calendar year. Detail on the calculations underlying the cost estimates for research space is presented in Table 7.

The average size or standard for faculty offices was ascertained for each university separately and this information was readily available from a campus planner at each institution. It is assumed here that each graduate faculty member needs and fully utilizes a faculty office of standard size for two-thirds of a calendar year. The total cost of graduate faculty office space was allocated to the cost of training Ph.D.'s, and is shown on Table 8.

The estimates of costs of physical facilities presented in Tables 6, 7, and 8, and in columns 3, 8, and 17 on the Summary of Components of Y_{ac} (Table 18 included in the Appendix) are based on optimal amounts of space rather than on actual amounts of space used. If the underlying space standards on which the cost estimates are based are subject to question, alternative space standards can readily be substituted in the calculations. As set forth in the above tables the total estimated cost of physical facilities constitutes an average of

8.3% of the total cost of a Ph.D. in Physics

10.0% of the total cost of a Ph.D. in Zoology

5.3% of the total cost of a Ph.D. in Sociology

14.9% of the total cost of a Ph.D. in English

ESTIMATION OF INDIRECT OR SUPPLEMENTAL COSTS

A number of diverse cost elements are included under Supplemental Costs as shown on the Summary of Components of Y_{ac} table for each discipline (Table 18 in the Appendix). Supplemental costs include costs of certain fixed inputs supplied by the university and shared by all types and levels of programs offered within the institution, as well as certain fixed inputs of the departments in which the four selected graduate programs are offered. The university's fixed inputs which were considered in the cost analysis consist of administrative and library services. On the departmental level, supplies, equipment, and clerical services, graduate faculty offices, fellowships and staff benefits were treated as supplemental cost elements. All costs which must be allocated on an equal basis to graduate course and graduate

TABLE 7

STUDENT RESEARCH SPACE COST (LAB AND OFFICE) PER GRADUATE STUDENT RESEARCH CREDIT HOUR

Universities	Number of Students in Department	Space Allocation per Student	Total Research (Student) Space Needed by Department	Rental Rate per Ft^2 per Year	Cost of Total Student Research Space Needed by Department per Year	Proportion of Calendar Year Represented by Academic Year	Total Cost of Total Student Research Space per Academic Year for Department	Total Research Credit Hours Produced by Department in a Year	Cost per Research Credit Hour	Cost per Research Semester Hour
Physics										
A	91	110	10,010	$2.75	$27,528	.67	$18,444	423	$ 43.60	$ 43.60
B	65	110	7,150	1.25	8,938	.75	6,704	472	14.20	14.20
C	63	110	6,930	5.00	34,650	.75	25,988	193	134.65	134.65
D	101	110	11,110	4.25	47,218	.75	35,413	222	159.52	159.52
E	75	110	8,250	2.81	23,183	.75	17,387	233	74.62	74.62
F	336	110	36,960	2.25	83,160	.75	62,370	2,464	25.31	25.31
G	113	110	12,430	4.00	49,720	.75	37,290	678	55.00	82.50
H	100	110	11,000	5.40	59,400	.75	44,550	615	72.44	108.66
I	199	110	21,890	4.00	87,560	.75	65,670	1,115	58.90	88.35
J	155	110	17,050	3.36	57,288	.75	42,966	694	61.91	92.87
K	170	110	18,700	4.00	74,800	.75	56,100	1,747	32.11	48.17
Zoology										
A	80	110	8,800	$2.75	$24,200	.67	$18,150	302	$ 60.10	$ 60.10
B	49	110	5,390	1.25	6,738	.75	5,054	185	27.27	27.27
C	67	110	7,370	5.00	36,850	.75	27,638	305	90.62	90.62
D	57	110	6,270	4.25	26,648	.75	19,986	132	151.41	151.41
E	43	110	4,730	2.81	13,291	.75	9,968	126	79.11	79.11
F	85	110	9,350	2.25	21,038	.75	15,779	1,138	13.88	13.88
G	57	110	6,270	4.00	25,080	.75	18,810	465	39.10	58.65
H	68	110	7,480	5.40	40,392	.75	30,294	582	52.05	78.08
I	43	110	4,730	2.90	13,717	.75	10,288	510	20.17	30.26
J	60	110	6,600	3.36	22,176	.75	16,632	148	112.38	168.57
K	52	110	5,720	4.00	22,880	.75	17,160	1,155	14.86	22.29
Sociology										
A	43	50	2,150	$2.75	$ 5,913	.67	$ 3,962	150	$ 26.41	$ 26.41
B	35	50	1,750	1.25	2,188	.75	1,641	195	8.42	8.42
C	45	50	2,250	5.00	11,250	.75	8,438	111	76.02	76.02
D	42	50	2,100	4.25	8,925	.75	6,694	276	24.25	24.25
E	55	50	2,750	2.81	7,728	.75	5,796	99	58.55	58.55
F	51	50	2,550	2.25	5,738	.75	4,304	232	18.54	18.54
G	92	50	4,600	4.00	18,400	.75	13,800	543	25.41	38.12
H	19	50	950	5.40	5,130	.75	3,848	350	10.99	16.49
I	116	50	5,800	1.70	9,860	.75	7,395	605	12.22	18.33
J	125	50	6,250	3.36	21,000	.75	15,750	786	20.04	30.06
K	82	50	4,100	4.00	16,400	.75	12,300	835	1.47	2.21
English										
A	64	50	3,200	$2.75	$ 8,800	.67	$ 5,896	1,474	$ 4.00	$ 4.00
B	152	50	7,100	1.25	8,875	.75	6,656	960	6.93	6.93
C	79	50	3,950	5.00	19,750	.75	14,813	108	137.16	137.16
D	88	50	4,400	4.25	18,700	.75	14,025	184	76.22	76.22
E	353	50	17,650	2.81	49,597	.75	37,198	462	80.52	80.52
F	252	50	1,250	2.25	2,813	.75	2,110	717	2.94	2.94
G	153	50	7,650	4.00	30,600	.75	22,950	243	94.44	141.66
H	151	50	7,550	5.40	40,770	.75	30,578	656	46.61	69.92
I	170	50	8,500	1.75	14,875	.75	11,156	785	14.21	21.32
J	318	50	15,900	3.36	53,424	.75	40,068	742	54.00	81.00
K	216	50	10,800	4.00	43,200	.75	32,400	1,328	24.40	36.60

TABLE 8

FACULTY OFFICE SPACE COST PER GRADUATE STUDENT CREDIT HOUR

Universities	Size of Average Faculty Office in Ft^2	Number of Members of Graduate Faculty	Total Graduate Faculty Office Space for Department	Rental Rate per Ft^2	Cost of Graduate Faculty Office Space per Calendar Year	Cost of Graduate Faculty Office Space per Academic Year	Number of Total Graduate Student Credit Hours Produced	Cost of Faculty (Graduate) Office Space per Graduate Student Credit Hour	Cost of Faculty (Graduate) Office Space per Graduate Student Semester Hour
				Physics					
A	166	19	3,154	$2.75	$ 8,673	$ 5,810	2,135	$2.72	$2.72
B	140	14	1,960	1.25	2,450	1,837	1,690	1.08	1.08
C	120	12	1,440	5.00	7,200	5,400	1,295	4.16	4.16
D	120	25	3,000	4.25	12,750	9,562	2,221	4.30	4.30
E	125	15	1,875	2.81	5,268	3,951	1,917	2.06	2.06
F	123	39	4,797	2.25	10,793	8,094	10,414	.78	.78
G	120	17	2,040	4.00	8,160	6,120	5,026	1.22	1.83
H	150	13	1,950	5.40	10,530	7,897	2,761	2.86	4.29
I	125	23	2,875	4.00	11,500	8,625	6,150	1.40	2.10
J	115	28	3,220	3.36	10,819	8,114	4,338	1.87	2.80
K	120	30	3,600	4.00	14,400	10,800	5,046	2.14	3.21
				Zoology					
A	166	22	3,652	$2.75	$10,043	$ 6,728	2,141	$3.14	$3.14
B	140	9	1,260	1.25	1,575	1,181	431	2.74	2.74
C	120	28	3,360	5.00	16,800	12,600	3,647	3.45	3.45
D	120	15	1,800	4.25	7,650	5,737	2,054	2.79	2.79
E	125	11	1,375	2.81	3,863	2,897	2,867	1.01	1.01
F	123	21	2,583	2.25	5.811	4,358	3,407	1.28	1.28
G	120	15	1,800	4.00	7,200	5,400	8,749	.62	.93
H	150	18	2,700	5.40	14,580	10,935	2,558	4.27	6.40
I	125	11	1,375	2.90	3,987	2,990	1,660	1.80	2.70
J	115	12	1,380	3.36	4,636	3,477	872	3.99	5.98
K	120	15	1,800	4.00	7,200	5,400	4,861	1.11	1.66
				Sociology					
A	166	11	1,826	$2.75	$ 5,021	$ 3,364	1,293	$2.60	$2.60
B	140	10	1,400	1.25	1,750	1,312	882	1.49	1.49
C	120	16	1,920	5.00	9,600	7,200	3,297	2.18	2.18
D	120	10	1,200	4.25	5,100	3,825	2,630	1.45	1.45
E	125	17	2,125	2.81	5,971	4,478	5,874	.76	.76
F	123	18	2,214	2.25	4,981	3,735	2,892	1.29	1.29
G	120	21	2,520	4.00	10,080	7,560	8,243	.92	1.38
H	150	11	1,650	5.40	8,910	6,682	1,735	3.85	5.77
I	125	23	2,875	1.70	4,887	3,665	3,731	.98	1.47
J	115	16	1,840	3.36	6,182	4,636	7,867	.59	.88
K	120	13	1,560	4.00	6,240	4,680	5,455	.86	1.29
				English					
A	166	21	3,486	$2.75	$ 9,586	$ 6,422	4,950	$1.29	$1.29
B	140	14	1,960	1.25	2,450	1,837	3,241	.57	.57
C	120	24	2,880	5.00	14,400	10,800	6,197	1.74	1.74
D	120	21	2,520	4.25	10,710	8,032	4,777	1.68	1.68
E	125	14	1,750	2.81	4,917	3,687	3,203	1.15	1.15
F	123	31	3,813	2.25	8,579	6,434	5,416	1.19	1.19
G	120	21	2,520	4.00	10,080	7,560	11,507	.66	.99
H	150	26	3,900	5.40	21,060	15,795	5,410	2.91	4.36
I	125	36	4,500	1.75	7,875	5,906	9,695	.60	.90
J	115	22	2,530	3.36	8,500	6,375	5,260	1.21	1.81
K	120	38	4,560	4.00	18,240	13,680	10,324	1.32	1.98

research credit hours earned by students are here classified as supplemental costs. All other costs are either specific to the course-taking phase or to the research phase of the Ph.D.

The cost of administrative services incorporates administrative costs at the aggregate university level as well as at the departmental level. Total university administrative expenses were allocated to each graduate program with the use of a ratio of departmental graduate student enrollment to total university enrollment. Departmental graduate administrative costs were allocated by using the percentage of total graduate faculty salaries of each department that corresponds to the average percentage of time spent by the graduate faculty on administrative duties. As shown in Table 9, the graduate departmental share of the university's general administrative expense was added to the cost of graduate departmental administrative services. Then the total administrative cost of the graduate program was converted to a graduate student credit hour basis.

The total annual cost of operating the university library was allocated to each graduate program in a manner analogous to the allocation of university general administrative expenditures, and library costs per graduate student credit hour are shown in column 13 of the Summary of Components of Y_{ac} (Table 18 of the Appendix).

In regard to departmental overhead expenses the following procedures were followed. Departmental budgets for supplies, equipment, and clerical services were first allocated between graduate and undergraduate enrollment in the department, and subsequently the graduate portion of those budgets was converted to a graduate student credit hour basis. The staff benefits cost consists of the university's contribution to staff benefits as an average percentage of total graduate faculty salaries. Universities generally calculate estimates for their contribution to staff benefits as an average percentage of total salaries, and each university's estimated average percentage was applied to total graduate faculty salaries of the four departments, and converted to a graduate student credit hour basis.

The estimating procedures applied to faculty office costs were described previously. Graduate faculty office costs are included as a supplemental cost because unlike classroom space and research space costs, the former must be allocated to both course and research credit hours. All supplemental costs are shown in columns 12-18 on the Summary of Components of Y_{ac} table (Table 18 of the Appendix).

Total fellowship funds of departments were also treated as a supplemental cost of the Ph.D. on the ground that society awards fellowships to students as an inducement to undertake graduate education. Objections may be raised at the inclusion of fellowship funds as they reflect neither the cost of a specific, tangible input of doctoral programs, nor the cost of students' time

TABLE 9

ADMINISTRATIVE COSTS PER GRADUATE STUDENT CREDIT HOUR

Universities	Total University General Administrative Expense	Departmental Graduate Enrollment / Total University Enrollment	Departmental Graduate General Administrative Expense (A)	Total Graduate Faculty Salary	% Time Devoted to Administration by Graduate Faculty	Departmental Graduate Faculty (Not General) Administrative Expense (B)	Departmental Graduate Total Administrative Expense (A & B)	Total Graduate Student Credit Hours Produced by Department	Cost per Graduate Student Credit Hour	Cost per Graduate Student Semester Hour
				Physics						
A	$1,626,927	.0075	$ 12,202	$212,280	10.0	$ 21,228	$ 33,430	2,135	$15.66	$15.66
B	1,779,890	.0099	17,621	165,075	12.0	19,089	36,710	1,690	21.72	21.72
C	1,000,000	.0135	13,500	110,500	11.0	12,155	25,655	1,295	19.81	19.81
D	3,786,096	.0075	28,396	296.736	16.0	47,477	75,873	2,221	34.16	34.16
E	1,494,582	.0053	7,921	64,325	5.0	8,216	16,137	1,917	8.42	8.42
F	2,913,594	.0094	27,388	453,888	10.6	45,389	72,777	10,414	6.98	6.98
G	2,703,918	.0278	75,169	231,650	11.0	25,482	100,651	5,026	20.03	30.04
H	3,518,000	.0093	32,717	159,012	10.0	15,901	48,618	2,761	17.61	26.41
I	3,557,991	.0286	101,759	493,079	8.0	39,448	141,207	6,150	22.96	34.44
J	1,195,991	.0040	4,784	316,527	10.0	31,653	36,437	4,338	8.40	12.60
K	3,291,568	.0065	21,434	320,398	13.0	41,652	63,086	5,046	12.50	18.75
				Zoology						
A	$1,626,927	.0066	$ 10,738	$262,550	10.0	$ 26,255	$ 36,993	2,141	$17.28	$17.28
B	1,779,890	.0074	13,171	127,775	14.0	17,889	31,060	431	72.06	72.06
C	1,000,000	.0144	14,400	287,976	19.0	54,715	69,115	3,647	18.95	18.95
D	3,786,096	.0043	16,280	171,600	10.0	17,160	33,440	2,054	16.28	16.28
E	1,494,582	.0030	4,484	128,790	9.0	11,591	16,075	2,867	5.61	5.61
F	2,913,594	.0024	6,993	249,866	13.3	33,232	40,225	3,407	11.81	11.81
G	2,703,918	.0135	36,503	195,300	20.0	39,060	75,563	8,749	8.64	12.96
H	3,518,000	.0063	22,163	238,053	12.0	28,566	50,702	2,558	19.82	29.73
I	3,557,991	.0062	22,060	169,780	8.0	13,582	35,642	1,660	21.47	32.21
J	1,195,991	.0016	1,913	135,505	20.0	27,101	29,014	872	33.27	49.90
K	3,297,568	.0020	6,595	161,154	11.0	17,727	24,322	4,861	5.00	7.50
				Sociology						
A	$1,626,927	.0035	$ 5,694	$130,100	9.0	$ 11,709	$ 17,403	1,293	$13.46	$13.46
B	1,779,890	.0053	9,433	128,540	14.0	17,996	27,429	882	31.10	31.10
C	1,000,000	.0097	9,700	160,020	13.0	20,803	30,503	3,297	9.25	9.25
D	3,786,096	.0031	11,737	113,900	26.0	29,614	41,351	2,630	15.72	15.72
E	1,494,582	.0039	5,829	162,300	9.0	14,607	20,436	5,874	3.48	3.48
F	2,913,594	.0014	4,079	190,452	15.0	29,520	33,599	2,892	11.62	11.62
G	1,812,391	.0347	62,890	274,850	32.0	87,952	150,842	8,243	18.30	27.45
H	3,518,000	.0018	6,332	124,800	10.0	12,480	18,812	1,735	10.84	16.26
I	3,557,991	.0167	59,418	384,592	11.0	42,305	101,723	3,731	27.26	41.89
J	1,195,991	.0033	3,947	195,297	13.0	25,388	29,335	7,867	3.73	5.59
K	3,297,568	.0032	10,552	133,329	13.0	17,333	27,885	5,455	5.11	7.66
				English						
A	$1,626,927	.0053	$ 8,623	$226,900	17.6	$ 39,934	$ 48,557	4,950	$ 9.81	$ 9.81
B	1,779,890	.0230	40,937	202,450	16.0	32,392	73,329	3,241	22.62	22.62
C	1,000,000	.0170	17,000	227,700	12.0	27,324	44,324	6,197	7.15	7.15
D	3,786,096	.0066	24,988	274,125	9.0	24,671	49,659	4,777	10.39	10.39
E	1,494,582	.0250	37,364	152,289	13.0	19,798	57,162	3,203	17.85	17.85
F	2,913,594	.0070	20,395	366,182	17.0	64,448	84,843	5,416	15.66	15.66
G	2,371,600	.0399	94,152	258,965	19.0	49,203	143,355	11,507	12.46	18.69
H	3,518,000	.0140	49,252	350,350	20.0	70,070	119,322	5,410	22.05	33.07
I	3,557,991	.0244	86,815	584,164	32.0	186,932	273,747	9,695	28.23	42.35
J	1,195,991	.0083	9,927	261,930	17.0	44,528	54,455	5,260	10.35	15.53
K	3,297,568	.0083	27,370	375,233	15.0	56,285	83,655	10,324	8.10	12.15

and effort. As noted before, the cost of inputs supplied by students is represented in the opportunity cost estimates, which were derived on the basis of fellowship data together with other data on earnings of graduate students. The inclusion of fellowship funds in the total cost estimates of this study is based on the assumption that the absence of fellowships might result in unwillingness to invest in the Ph.D. on the part of some potential fellowship recipients. Without fellowships some students might reject the opportunity to attend graduate school irrespective of earnings possibilities in the form of teaching or research assistantships. Also the relative supply of graduate fellowships in a given discipline may well have some influence on the quantity and/or quality of students attracted to its graduate programs vs. graduate programs in disciplines with a larger or smaller supply of fellowships. Thus interpreted the fellowship cost represents a social cost of inducement into graduate education in general, or into a particular field of graduate education. Inasmuch as fellowship holders can complete the doctorate within a shorter period of time than teaching fellows and research assistants the fellowship cost may also be viewed as a social cost of accelerating the production of Ph.D.'s.

In general only a fraction of the total number of graduate students in a department receive fellowship support. Total departmental fellowship funds of 1964-65 are allocated to the average cost of Ph.D.'s on a graduate student credit hour basis. Allocated in this manner the contribution of fellowships to the total cost of a Ph.D. may be viewed in the light of other component costs. Fellowship costs per credit hour are shown in column 15 of the Summary of Components of Y_{ac} table (Table 18 of the Appendix). Total fellowship costs as an average percentage of Y_{ac} in the four disciplines amount to the following:

3.8% in Physics

8.9% in Zoology

8.4% in Sociology

6.2% in English

CHAPTER V

THE FINDINGS ON COST—DISCUSSION AND STATISTICAL ANALYSIS

Two sets of estimates are presented for total costs of Ph.D.'s: Y_{ac}—the average total cost of a Ph.D., and the sum of Y_{ac} and the opportunity cost. As seen in Table 3 the average Y_{ac}'s for Sociology and for English are less than one-half of the average Y_{ac}'s for Physics and for Zoology, which are quite similar to each other. Furthermore, the average Y_{ac} for English is less than that for Sociology. Nevertheless, the ranges for Y_{ac} in the four disciplines overlap to some extent.

When the opportunity cost is added to Y_{ac}, differences between the total costs in the four disciplines change; the difference between average Y_{ac} in Physics and Zoology increases, and the differences between average Y_{ac} of the Natural Sciences on the one hand, and of Sociology and English on the other, decrease. These changes in the relative total social costs per Ph.D. in the four disciplines when opportunity costs are included result primarily from the difference in number of years required to complete the doctorate in the respective fields.

An examination of the data presented in previous tables reveals that within each discipline there is considerable variation around the means of credit hour requirements, cost components, and the total cost of the Ph.D. Undoubtedly some of the variation in the cost estimates and in the many variables upon which the cost estimates are based, is attributable to the heterogeneity of participating universities. However, there are additional factors which contribute to the variation of costs of a Ph.D. within as well as among disciplines. A number of variables were subjected to statistical analysis in order to determine the factors that are associated with inter- and intradisciplinary variability of the cost of a Ph.D. The following analyses were carried out:

(1) Comparison of cost within and among disciplines

(2) Regression analysis of factors related to Y_{ac}

(3) Analysis of curriculum differences and the effect of curriculum on the cost

(4) Analysis of differences in research support, fellowship support, and the total research cost of the Ph.D.

(5) Analysis of time distribution data of graduate faculty

COMPARISON OF COST WITHIN AND AMONG DISCIPLINES

Differences Among Disciplines

Since the average difference in Y_{ac} between any two disciplines ranged from about $4,000 to $25,000, a series of tests were applied to examine the significance of these differences. The results of these analyses of variance are formulated as follows:

where $Y_{ac}P$ = average cost of training a Ph.D. in Physics
$Y_{ac}Z$ = average cost of training a Ph.D. in Zoology
$Y_{ac}S$ = average cost of training a Ph.D. in Sociology
$Y_{ac}E$ = average cost of training a Ph.D. in English,

$$Y_{ac}P,\ Y_{ac}Z \ > \ Y_{ac}S,\ Y_{ac}E$$

$$Y_{ac}P \ \not> \ Y_{ac}Z$$

$$Y_{ac}S \ \not> \ Y_{ac}E \qquad \alpha = .05$$

These equations indicated that at the 5% confidence level Y_{ac}'s for both Physics and Zoology are significantly larger than the Y_{ac}'s for both Sociology and English. However, at the same confidence level, the difference in Y_{ac} between Physics and Zoology, and the difference between Sociology and English are not significant.

Differences Between Public and Private Universities in Each Discipline

An analysis of variance was carried out to examine the differences in total cost of the Ph.D. between departments of public and private universities in each discipline. In every discipline the differences in Y_{ac} between public and private universities were found to be not significant at the 5% level. The results are formulated as follows:

Where:

Y_{ac} Public = the average cost of training a Ph.D. in a given discipline at public universities
Y_{ac} Private = the average cost of training a Ph.D. in a given discipline at private universities

$$Y_{ac} \text{ Public } \ngtr Y_{ac} \text{ Private} \qquad \alpha = .05$$

True in each of the four disciplines.

REGRESSION ANALYSIS OF FACTORS RELATED TO Y_{ac}

Multiple and Partial Correlation Analysis of Different Variables Upon Y_{ac}

Within each discipline Y_{ac} varies widely from department to department. In order to explain the variation in Y_{ac}, multiple and partial regression analyses were carried out to determine the degree of association of a number of variables with variation in the total cost of training a Ph.D. The multiple regression analysis was run to test the following hypotheses:

1. Do graduate departments exhibit economies of scale, i.e., does the cost of a Ph.D. vary inversely with the number of graduate students enrolled in the department.
2. Do certain qualitative factors such as the faculty-student ratio and average faculty salaries show a relationship to Y_{ac}.
3. Is the extent to which a department engages in research positively reflected in Y_{ac}, i.e., are such variables as volume of departmental research expenditures and percentage of the faculty workweek devoted to research directly related to Y_{ac}.
4. Differences in the "representative curriculae" also cause variability in Y_{ac} and this effect will be analyzed in a later section.

The multiple correlation included six independent variables, namely:

1. Size (expressed in terms of number of graduate students enrolled in a department)
2. Faculty-student ratio
3. Average faculty salaries
4. Size of the total departmental research budget
5. Average per cent of faculty workweek spent on research
6. Total number of credit hours in the "representative curriculum"

The results of the multiple and partial regression in the four disciplines are set forth below.

Where:

B = Dollar volume of annual departmental research budgets
C = Size of curriculum in credit hours
P = Average percent of time the graduate faculty spends on research

R = Ratio of faculty to students
S = Size of department in terms of number of graduate students enrolled
W = Average salary of graduate faculty members

Where $\alpha = .05$

Physics

$$(a)\quad Y_{ac}P = -41{,}910 + \underset{(.008)}{.03(B)} \underset{(45.4)}{-213.4(S)} + \underset{(163.0)}{538.3(C)} + \underset{(383.8)}{820.1(P)} \qquad R^2 = .887$$

Zoology

$$(b)\quad Y_{ac}Z = -31{,}070 + \underset{(.019)}{.04(B)} + \underset{(2.8)}{7.3(W)} - \underset{(589.4)}{1{,}091.9(P)} \qquad R^2 = .679$$

Sociology

$$(c)\quad Y_{ac}S = -82{,}179.7 + \underset{(0.9)}{5.3(W)} + \underset{(121.3)}{521.5(C)} - \underset{(43.5)}{163.9(S)} \qquad R^2 = .836$$

English

$$(d)\quad Y_{ac}E = 353.9 + \underset{(257.4)}{490.0(P)} \qquad R^2 = .287$$

Using the same data, partial correlation analysis was carried out to test the net effect of each variable on Y_{ac}. The relative strength of the simple and partial correlation coefficient can be compared for each explanatory variable.

SIMPLE AND PARTIAL CORRELATION COEFFICIENTS*
Physics (df = 6)

	Y_{ac}	S	B	P	r_p
S	-.23				-.88
B	.68	.29			.84
P	-.01	.14	-.10		.66
C	.36	.66	.50	-.20	.80

---

*Figures in the triangular matrix are coefficients of simple correlation. r_p is the partial correlation coefficient for the independent variable and Y_{ac}.

Zoology (df = 7)

	Y_{ac}	B	P	r_p
B	.59			.62
P	.05	.28		-.57
W	.58	.31	.57	.70

Sociology (df = 7)

	Y_{ac}	S	W	r_p
S	-.21			-.82
W	.40	.52		.91
C	.22	.22	-.60	.85

As for the hypotheses

1. Economies of scale appear to exist in Physics and Sociology, but not in English. For Zoology S(size) enters the correlation after B,P, and W; it raises the R^2 from .679 to .743, but there is a large drop in the F level.

2. Concerning the relationship between certain qualitative factors and Y_{ac}: the faculty-student ratio did not enter into any of the regression equations at a significant F level. Average faculty salary accounts for a certain percent of the variance in Y_{ac} in Zoology and Sociology: 70% and 91%, respectively, when other variables are held constant. Average faculty salary played a very minor part in explaining the variance of Y_{ac} in Physics.

3. In Physics and Zoology total departmental research expenditures together with percentage of faculty time devoted to research account for a substantial amount of variation in Y_{ac}. In Sociology neither the departmental research expenditures nor the percentage of faculty time spent on research helped to explain the variation in Y_{ac}. In English the percentage of faculty time spent on research is the only variable that entered into the multiple regression equation at a significant F level.

Relationship Between Y_{ac} and Total Annual Expenditures Per Student

In order to test the validity of the method used to calculate Y_{ac}, an alternative approach was used to calculate the total cost of training Ph.D.'s and the results of the two methods were compared. The same set of inputs is included in both cost calculations, the difference being that Y_{ac} is based on the cost of the "representative curriculum" whereas the alternative approach is based on a figure representing total annual expenditures per student. This figure is derived by dividing the 1964-65 cost of all allocated inputs of each department's doctoral program by its 1964-65 total graduate enrollment. This figure included the portion of faculty salaries allocated to graduate training, the allocated portion of the research budgets, the annual cost of utilizing physical facilities, and the corresponding supplemental costs.

Columns 7 and 8 in Table 3 show the total annual expenditures per graduate student for 1964-65 and Y_{ac} for each department in each discipline, and Figure 2 (scatter diagram) presents the relationship between total yearly expenditures per student and Y_{ac}. This relationship is further elaborated in Table 10 which presents estimated time spent on the doctorate in comparison to average actual time spent on the doctorate for each discipline. The estimated figure is derived simply by dividing total annual expenditures per student (E/S) into the total cost per Ph.D. (Y_{ac}). Table 3 shows that for Physics and Zoology the average estimated time is a close approximation of average actual time spent on the doctorate, whereas for Sociology and English, the estimated time is only roughly one-half of the average actual time. The above differences are believed to be related to the fact that the concept of fully-enrolled student is more applicable to graduate students in the Sciences, and is applicable to more years of graduate study in the Sciences than is the case in Sociology and English.

TABLE 10

RELATIONSHIP BETWEEN ESTIMATED TIME AND AVERAGE ACTUAL TIME SPENT ON THE DOCTORATE

Discipline	Total Annual Expenditures per Student	Y_{ac}	Average Estimated Time for the Doctorate (years)	Average Actual Time Spent on the Doctorate (years)
Physics	$6,061	$36,934	6.02	5.9
Zoology	$5,645	$32,511	5.82	6.7
Sociology	$4,864	$15,970	3.55	7.4
English	$3,283	$11,098	4.42	8.3

For each discipline separately and also for the forty-four departments as one group a simple correlation analysis between E/S and Y_{ac} was run, and the following coefficients of determination were obtained:

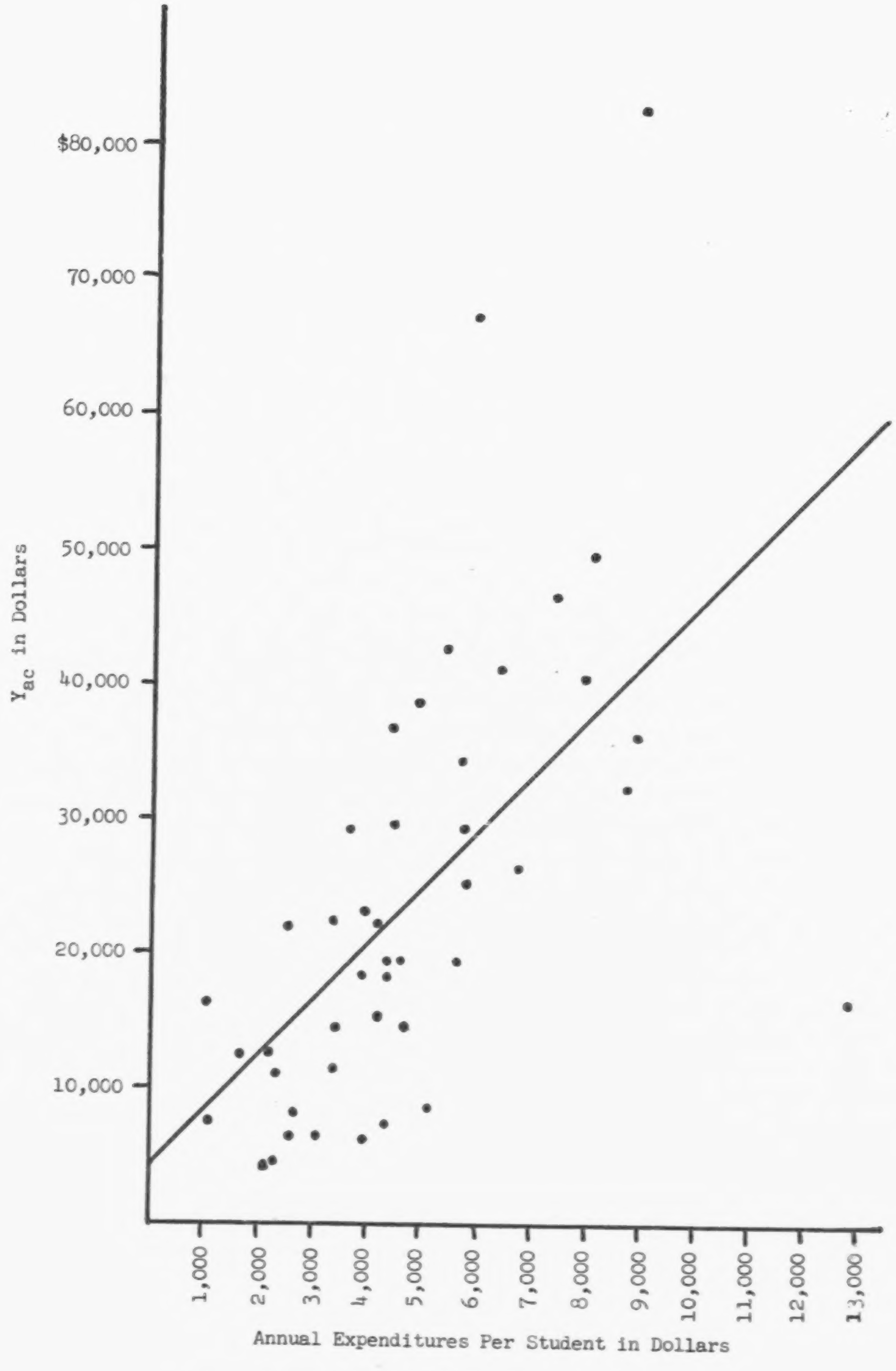

Figure 2. Relationship between Y_{ac} and total annual expenditures per student.

For 44 departments:	R^2	= .341
Physics	R^2	= .514
Zoology	R^2	= .196
Sociology	R^2	= .093
English	R^2	= .041

On the scatter diagram there are three cases which do not conform to the general trend. When these three departments are omitted from the correlation analysis an R^2 of .557 is obtained for 41 departments. The nonconforming departments consist of one department in Physics, one in Zoology, and one in Sociology. As for the R^2's for individual disciplines, the degree of association between total annual expenditures per student and the total cost per Ph.D. is by far the strongest in Physics.

The following inference may be drawn from the above analysis: Given the current state of record keeping on graduate programs, measurement of Y_{ac} by means of total yearly expenditures per student, will yield estimates which are considerably less accurate than those derived with the use of curriculum cost analysis. It appears that the degree of association between E/S and Y_{ac} for a given department tends to be weakened by two types of factors:

(1) The inadequacy of graduate enrollment data. More specifically,
    (a) the inability of departments to convert the number of enrolled graduate students into full-time-equivalent graduate students, and
    (b) the inability of departments to classify enrolled graduate students by level of graduate study.

(2) An inequality (which frequently cannot be specified) between imported and exported graduate student credit hours of a graduate program. Imported graduate student credit hours are those earned by a given department's graduate students in other departments Exported graduate student credit hours are those produced by a graduate department for students other than its own graduate students.

On the assumption that there will be continued improvement in the quality and quantity of information both on graduate departmental enrollments and on graduate departmental credit hour production, the E/S approach may be developed into an alternative method of approximating the total cost of Ph.D.'s. At the present time, however, the state of record keeping on doctoral programs appears to rule out any meaningful application of this approach.

ANALYSIS OF CURRICULUM DIFFERENCES AND THE EFFECT OF CURRICULUM ON COST

The Effect of Curriculum Differences on Cost

Differences in the "representative curriculum" of departments within the same discipline constitute one source of variation in Y_{ac}. There are two ways in which the "representative curriculae" can differ:

(1) Differences in the number of total credit hours earned by a sample of Ph.D. recipients.

(2) Differences in the distribution of total credit hours between course credit hours and research credit hours.

In order to remove the effect of curriculum differences on Y_{ac}, a constant curriculum was calculated for each discipline. This consists of an average of the "representative curriculea" of all departments in a given discipline with respect to both total number and distribution of credit hours. Then Y_{ac} was recalculated applying the constant curriculum to each department within a discipline. The constant curriculum cost per Ph.D. is called Y_{cc}. A simple correlation between Y_{ac} and Y_{cc} for all departments in each discipline shows the net effect of curriculum differences on the total cost per Ph.D. The results are given in Table 11

TABLE 11

THE EFFECT OF CURRICULUM DIFFERENCES ON VARIATION IN Y_{ac}

Discipline	Correlation between Y_{ac} and Y_{cc}	Curriculum Influence on Y_{ac}
Physics	.698	30.2%
Zoology	.874	12.6%
Sociology	.713	28.7%
English	.409	59.1%

Where:

X_c = Cost of producing a course credit hour per student

X_r = Cost of producing a research credit hour per student

C_c = Number of course credit hours in the curriculum

C_r = Number of research credit hours in the curriculum

Y_{ac} = Cost of training a Ph.D. based on variable curriculum

Y_{cc} = Cost of training a Ph.D. based on constant curriculum

$$\text{(a)}\quad X_{c_1} C_{c_1} + X_{r_1} C_{r_1} = Y_{ac_1}$$

$$\text{(b)}\quad X_{c_1} \bar{C}_c + X_{r_1} \bar{C}_r = Y_{cc_1}$$

Differences in Curriculae

An analysis of variance was carried out to test whether curriculum differences among the disciplines are significant. The results showed that at the 5% level none of the curriculum differences between disciplines are significant.

Further analyses of variance were carried out to test if there were statistically significant curriculum differences between the public and private universities in any one discipline. With respect to both total credit hours and research or thesis credit hours, there were no significant differences between the curriculae of public and private universities for any of the four disciplines at the 5% level. With respect to course credit hours, the average for Zoology departments in public universities was significantly larger than the average for private universities, but similar differences were not significant in the other three disciplines.

ANALYSIS OF RESEARCH SUPPORT, FELLOWSHIP SUPPORT, AND THE RESEARCH COST OF THE Ph.D.

Research Support

An analysis of variance was carried out to test the significance of the differences in research support among the three disciplines having research funds, i.e., Physics, Zoology, and Sociology. All differences among the three disciplines were found to be significant at the 5% level. This can be formulated as follows:

Where:

B_p = average total research funds for Physics departments

B_z = average total research funds for Zoology departments

B_s = average total research funds for Sociology departments

$$B_p > B_z > B_s \qquad \alpha = .05$$

With respect to differences between research funds of public and private universities, an analysis of variance showed that Zoology departments in private universities had a significantly larger volume of funds than those in public universities. However, the differences in the other disciplines were not significant at the 5% level.

Fellowship Support

Analysis of variance was used to examine the differences in total fellowship support received by the departments in each discipline. It was found that at the 5% level, departments in any given discipline did not differ significantly from departments in any other discipline with respect to the total fellowship support received by their students.

A similar test was employed to study the differences in fellowship support between public and private institutions. Both the Zoology and English departments of private universities received significantly larger amounts of fellowship support than the departments of public universities. However, in Physics and Sociology similar differences were not significant at the 5% level.

The Research Cost of the Ph.D.

Analyses of variance were used to examine the differences in the average cost of the research phase of the Ph.D. among the four disciplines. These tests showed that at the 5% level, the average costs of the research phase in Physics and Zoology are significantly higher than the corresponding costs in Sociology and English. However, neither the difference in research cost between Physics and Zoology, nor the difference in research cost between Sociology and English, were significant. These results are formulated as follows:

Where:

R_p = cost of the research phase of the Ph.D. in Physics

R_z = cost of the research phase of the Ph.D. in Zoology

R_s = cost of the research phase of the Ph.D. in Sociology

R_e = cost of the research phase of the Ph.D. in English

$$R_p, R_z > R_s, R_e$$

$$R_p \ngtr R_z$$

$$R_s \ngtr R_e$$

$$\alpha = .05$$

Another analysis of variance was carried out to examine the differences in cost of the research phase between public and private universities in the same discipline. At the 5% level it was found that in all disciplines there were no significant differences in cost of the research phase between departments in public universities and in private universities.

ANALYSIS OF LENGTH OF THE WORKWEEK AND TIME DISTRIBUTION OF THE GRADUATE FACULTY

Analysis of variance was used to examine differences in length of the workweek of graduate faculty in the four disciplines. It was found that at the 5% level there were no significant differences in average number of hours worked per week by graduate faculty in the four disciplines.

The same type of test was used to determine whether workweeks differed significantly between departments of public and private universities in each discipline. It was found that at the 5% level the differences were not significant in any discipline. The average length of the workweek in the four disciplines ranges from approximately 54 to 56 hours.

Faculty time distribution data are frequently criticized as being arbitrary and unreliable both by the faculty members who are suppliers of the data and by institutional researchers who are the compilers and potential users of the data. If it is legitimate to assume that the greater the uniformity of the data gathered from graduate faculty of different disciplines and universities the greater the likelihood that they are descriptive of actual time patterns of professional activities, the compiled data may be less subjective in nature than is generally assumed. The faculty time distribution data compiled in this study are presented in Table 2 and on Figures 3 and 4 in the Appendix. A different set of data on faculty time distribution was compiled as part of the 1964 Cartter study on quality in graduate education. Table 12 presents a comparison of Cartter's data and my data for the four disciplines in question. Cartter's data were gathered from 106 universities and from one to four faculty members of each department, with the departmental chairman always included. The fact that Cartter's data on "all respondents" are heavily weighted with responses from departmental chairmen accounts for the fact that his figures are consistently higher on administration and consistently lower on research. Generally speaking the time division patterns outlined by the two sets of data show a fair amount of correspondence.

Assuming that the reported cost estimates present a reasonably accurate picture of the costs of Ph.D's at the time these estimates were made, one may question the extent to which the estimates lend themselves to extrapolation into the future. The estimates are based on representative curriculae of graduate students who received their doctorates between 1958 and 1964, and on financial data of the year 1964-65. Irrespective of possible revision of "representative curriculae" the estimates will become outdated rapidly if costs of higher education rise at the rate at which they have increased in the last two decades. If the Y_{ac}'s of the four disciplines are equally affected by future price increases the estimates are somewhat more reliable in providing perspective on relative costs of Ph.D.'s in four disciplines, than they are in defining the range of absolute costs which may prevail in future years.

TABLE 12

DIVISION OF TIME FOR PROFESSIONAL ACTIVITIES

(Comparison of Data in Cartter's Study and in This Study*)
(in percent)

All Respondents	Instruction			Research and Writing	Adminis-tration	Other
	Under-graduate	Graduate	Total			
Physics:						
Cartter Study	19	28	47	23	22	8
This Study	16	30	46	39	11	5
Zoology:						
Cartter Study	26	21	47	26	21	7
This Study	19	21	40	36	13	10
Sociology:						
Cartter Study	23	23	46	26	19	9
This Study	17	25	42	35	15	9
English:						
Cartter Study	25	24	49	19	26	7
This Study	28	27	55	22	17	6

*Since the Cartter study used a questionnaire which was phrased somewhat differently from ours, two categories on his questionnaire and two categories on our questionnaire had to be combined to make the two sets of data comparable. The above table is based on combining the data on "Other Professional" and "Other" compiled in Cartter's study and on combining the data on "Graduate Instruction" and "Graduate Student Supervision" compiled in this study.

No hypotheses were formulated regarding the level of costs of graduate education prior to the undertaking of this study. No attempt was made to demonstrate either that graduate education is expensive or that the cost of graduate education is reasonable, or that graduate students in the sciences should be charged higher fees than those in Sociology and English. If the estimates here presented are biased in any direction they are likely to be conservative. In all cases where the information was either questionable or incomplete. The most conservative of alternative methods were used to derive imputations.

CHAPTER VI

RATES OF RETURN

This chapter reports the procedure and findings of the rate of return analysis. So far this report has dealt almost exclusively with the derivation, analysis, and discussion of total social costs of graduate education in four disciplines. Society's total investment in graduate education comprises the dollar value of all inputs that enter into doctoral programs thus included in Y_{ac} and the opportunity cost. Estimation of the monetary investment yields to society is based on the total social costs of Ph.D.'s together with before-tax net salary differentials associated with graduate education of Ph.D.'s. This chapter proceeds as follows: (1) Incorporation of cost into the rate of return analysis, (2) Derivation of lifetime net salary differentials, (3) Estimating the rates of return, (4) The findings, and (5) Discussion of the findings.

INCORPORATION OF COST INTO THE RATE OF RETURN ANALYSIS

In previous chapters the average total social cost of a Ph.D. and the investment period of the Ph.D. in four disciplines were specified. The investment period for a discipline is taken to be the average number of years spent on the doctorate in the surveyed university departments of that particular discipline. The first step in the rate of return computations is to convert the average total social cost for each of the four disciplines into present value cost streams. The following is one of Becker's formulas adapted to the present purpose*:

$$C = \sum_{j=0}^{n'} \frac{c_j}{(1+r)^j}$$

Where:

C = the present value of the total social cost of the Ph.D.

n' = the average number of years spent in obtaining the Ph.D.-1**

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*Gary S. Becker, Human Capital, New York, 1964, p. 38, equation 18.

**The cost stream starts with year 0 because cost in the first year should not be discounted. Thus n' becomes average number of years spent in obtaining the Ph.D.-1.

j = any year from 0 through n'

c_j = the cost of training a Ph.D. in year j

r = the market discount rate (assumed to be 5% throughout the investment period)

The assumption that cost outlays per year are constant over the entire period of graduate training is implicit in the discounted cost stream. Other parts of the study suggest that costs are lower in initial years and rise during the latter part of graduate education. However, to arrive at an empirical distribution of the total social costs of the Ph.D. over the specified investment period, would have required types of data that were not available.

It should be noted also that returns to the investment in Ph.D.'s as measured in this analysis do not begin to accrue until the total investment is completed, i.e., the conferment of the Ph.D. degree. Measurement of the yield starts in period 1 which is the first year after completion of the doctorate. In fact, returns may in some cases be realized before completion of the Ph.D. degree, as for example by those who take full-time jobs in the profession prior to receipt of the degree. As mentioned earlier, this phenomenon occurs with greater frequency in some disciplines than in others. Such returns have been taken into account to a certain extent, as was explained in the discussion of opportunity cost estimates.

It should be mentioned furthermore, that the opportunity cost portion of the total social cost of Ph.D.'s is derived on the basis of the same source of cross sectional salary data for bachelor degree holders which are used in the estimation of lifetime earnings differentials between terminal Bachelor and Ph.D. degree holders. Rates of return can also be calculated on the basis of Y_{ac} only, with allowance for opportunity costs by means of negative earnings differentials between Bachelor degree holders and Ph.D.'s during the latter's period of graduate training.

DERIVATION OF LIFETIME NET SALARY DIFFERENTIALS

In this study, returns on the investment in Ph.D.'s are measured over the following period: (a) it is assumed that earnings of the Ph.D. in a given field start at age 22 + the average number of years spent on obtaining the doctorate in that discipline; and (b) it is assumed that Ph.D.'s continue to earn salaries until age 65. With these two assumptions the boundaries of the income streams of Ph.D.'s become defined.

The basic source of salary data used in this analysis is the National Science Foundation's _National Register of Scientific and Technical Personnel_,

1964. More specifically, the data compiled for Physics, Biological Sciences, Sociology, and Linguistics were used in the rate of return estimates. The earnings of Zoologists are included in the Register but not separately presented and analyzed from earnings of Biological Scientists. It is assumed that use of salary data on Biological Scientists in general, rather than on Zoologists in particular, will not distort the results of the analysis. Salary figures on Linguistics were used to estimate earnings streams for the English profession for two reasons: (1) in order to make the rate of return estimates consistent for the four professions it seemed desirable to base lifetime earnings streams in the four fields on salary data from the same source; and (2) Linguistics is the only profession included in the 1964 Register whose salaries may be assumed to be reasonably close to the English profession. Crude comparisons of earnings of Linguists as reported in the 1964 Register with other data on earnings in the English profession suggest that the discrepancies in salaries of the two groups may be very minor. Nevertheless, the use of salary data of a profession other than the one whose rate of return is being calculated constitutes a regretable deficiency.

The National Register presents median annual salaries for scientists by discipline, highest degree, age, years of experience, type of employer, work activity, and a number of other characteristics of scientists. Disciplines vary with respect to the number of years they have been included in the Register and also in coverage. Sociology and Linguistics were included for the first time in the 1964 Register, which could imply more limited coverage for those two fields than for others which had participated in a number of previous N.S.F. salary surveys. Naturally disciplines also vary in size, i.e., number of scientists in any given discipline. According to inclusion of number of scientists in the 1964 Register Chemists constitute the largest group and Linguists the smallest.

Certain limitations are inherent in the National Register's salary data such as: unknown biases resulting from voluntary participation, incomplete information, i.e., possibly inadequate inclusion of irregular types of earnings such as royalties, consulting fees, summer earnings of academic scientists, etc., and the presentation of all salary statistics in the form of medians only.* As is true of most data, the Register data are deficient in some way relative to what is required for a particular purpose or analysis. With respect to the present study the National Register salary data represent first and foremost a very important asset. In fact, it constitutes the only source of inter-professionally comparable data on salaries of professionals with Ph.D.'s, also reporting a set of additional and important facts on the included scientists.

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*H.S. Houthakker argues that median incomes are not appropriate for estimating lifetime income streams and Edward F. Renshaw argues for the use of median income differentials. See: H. S. Houthakker, "Education and Income," Review of Economics and Statistics, February, 1959, pp. 24-28, and Edward F. Renshaw, "Estimating the Returns to Education," Review of Economics and Statistics, August, 1960, pp. 318-328. At any rate, there was no choice as far as this study is concerned because median salaries of professionals constitute the only form of earnings data available.

The two main shortcomings of the N.S.F. data for the purpose of estimating rates of return on the investment in Ph.D.'s are the following: the Register provides no information on starting salaries; and all the published data are presented in two-dimensional form, i.e., salary is related to a single characteristic whereas this study requires more detail on the relationship between age, education, and earnings. A further limitation relates to the fact that all cross sectional data are presented with respect to defined intervals. These intervals may or may not represent natural cutting points, but in either case one is forced to work with the intervals as given.

A description follows of the ways in which the N.S.F. data were adapted for use in this study. The task of estimating rates of return requires two representative lifetime earnings streams, namely, one for terminal bachelor degree holders, and one for Ph.D.'s for each discipline. Given the above limitations of the data, a procedure had to be developed for projecting separately the growth of salary over the working life, of terminal bachelor degree holders and for that of Ph.D.'s, utilizing the N.S.F. cross sectional data both for deriving starting salaries and for deriving earnings profiles related to the starting salaries, for both groups. It must be restated that the National Register does not present separate sets of cross sectional earnings statistics for terminal bachelor degree holders and Ph.D.'s in any discipline.

Derivation of Starting Salaries

The terminal Bachelor degree holder and the Ph.D. begin to earn salaries at a different age. The terminal Bachelor degree holder begins his earning period at the assumed age of 22. The Ph.D. begins to earn his salary at the assumed age of 22 + n years, or at age 22 + the average number of years spent on a Ph.D. in his particular discipline. This age of 22 + n years will be referred to as the assumed "professional age." As noted earlier, the negative differential in earnings realized by the terminal Bachelor degree holder and the potential Ph.D., during the years preceding the "professional age," has been accounted for in the opportunity cost estimates. For the purpose of estimating rates of return, measurement of the lifetime net earnings differential between terminal Bachelors and Ph.D.'s commences at the "assumed professional age" of each discipline.

The starting salaries of terminal Bachelors and Ph.D.'s of each discipline were determined with the use of N.S.F. cross sectional data on median annual salaries by age. For the terminal Bachelor in a particular discipline the median annual salary of all scientists in that discipline in the age group of 20-24 was assumed to be the starting salary. Considering the number of years required to obtain a Ph.D. degree in any discipline, it is unlikely that this age group includes Ph.D.'s. However, the age group 20-24 may contain some professionals without a Bachelor degree and some with education beyond the Bachelor. Conceivably the net effect on salary would be neutral.

The median annual salary of all scientists in a discipline, in the age group which includes "the assumed professional age," is assumed to be the starting salary for the Ph.D. This selection of starting salaries for Doctorate holders may be justified with the assumption that initial salaries of Ph.D.'s are probably comparable to those of others in the same profession and age group, who have less education but more experience.

Developing the Earnings Profiles

Given the above derivation of starting salaries, earnings profiles were projected using an index based on cross sectional salary data not by age but by years of professional experience for each discipline. In the absence of a separate set of cross sectional salary data for terminal Bachelors and Ph.D.'s in each discipline it was necessary to assume that an index of salary growth based on a single earnings profile of the profession, when applied to the starting salaries of both terminal Bachelors and Ph.D.'s would reflect with reasonable accuracy the actual difference in earnings profiles of the two groups. The salary growth index was taken from the N.S.F. cross sectional data for incomes by years of professional experience for all scientists in a given discipline. The N.S.F. data are presented in the form of median annual salaries of professionals grouped by intervals which are based on years of experience. The median annual salary of each interval was applied equally to each year contained in the interval. The index was derived simply by dividing the salary of any interval by the salary of the first interval, i.e., the median annual salary earned at one year of experience. Thus the index represents the ratio of salary earned in any interval to the median annual starting salary. The N.S.F. cross ectional data and the resulting index for each discipline are shown in Table 13.

It should be noted that applying the same index to both groups does not result in equal increments in income growth over the working life of terminal Bachelors and Ph.D.'s for the following reasons: (1) for any age from "the assumed professional age" until income has rached its peak for the Ph.D. the index number applied to the starting salary is different for both groups; and (2) the starting salaries of the two groups are different.

Given the starting salaries for both groups and the index for salary growth, earnings profiles can be constructed for both terminal Bachelors and for Ph.D.'s. For both groups the index number corresponding to appropriate

TABLE 13

SALARY GROWTH INDICES AND SUPPORTING DATA

Discipline	Number of Years of Professional Experience					
	1	2-4	5-9	10-14	15-19	20+
PHYSICS						
All Professionals:						
Median Salary*	$8,100	$8,600	$10,700	$13,500	$14,600	$15,200
Salary Growth Index**	1.00	1.06	1.32	1.67	1.80	1.88
ZOOLOGY						
All Professionals:						
Median Salary	$7,200	$7,500	$9,200	$11,000	$12,400	$14,100
Salary Growth Index	1.00	1.04	1.28	1.53	1.72	1.96
SOCIOLOGY						
All Professionals:						
Median Salary	$7,500	$8,100	$9,000	$10,200	$11,200	$12,500
Salary Growth Index	1.00	1.08	1.20	1.36	1.49	1.67
ENGLISH						
All Professionals:						
Median Salary	$6,500	$7,100	$8,000	$ 9,200	$10,000	$12,400
Salary Growth Index	1.00	1.09	1.23	1.42	1.54	1.91

*Source: "Median Annual Salaries of Full-Time Employed Civilian Scientists; By Field and Years of Professional Experience," Table 19, *1964 National Register*.

**Ratio of the salary for each interval to the salary of the first interval.

experience intervals was multiplied by the respective starting salary, for each year from the "assumed professional age" to age 65. Thus a separate income profile is produced for the working life of terminal Bachelors and Ph.D.'s of the same profession. Table 14 and Figure 5 in the Appendix show the two earnings profiles for each discipline. The earnings profiles of terminal Bachelors and Ph.D.'s in the same discipline were then expanded into lifetime earnings streams, which yield a stream of annual earnings differentials. The stream of annual before-tax earnings differentials when adjusted with mortality statistics, is taken to be the direct monetary yield to society on the investment in a Ph.D.

ESTIMATING THE RATES OF RETURN

In measuring the investment yields of graduate education the approach followed here involves calculation of internal rates of return. The internal rate of return is that rate of discount that equates the present value of the cost stream with the present value of the stream of earnings differentials. In the context of this study the cost stream represents the total social costs of training Ph.D.'s and the stream of salary differentials represents the lifetime, before-tax net earnings differences between terminal Bachelors and Ph.D.'s. The formula used in the computations was again taken from Becker's chapter on Rates of Return,* which is as follows:

$$C = \sum_{1}^{n} \frac{k_j}{(1+r)^j}$$

where in any given discipline:

C = the present value of the total social cost of the Ph.D.

n = length of post-Ph.D. employment, i.e., the earnings period of the Ph.D. in years

k_j = the annual salary differential between a terminal Bachelor and a Ph.D. in period j.

j = any year from 1 to n

r = the internal social rate of return on society's total investment in a Ph.D.

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[*] op. cit., p. 39, Formula (21).

TABLE 14

PROJECTED EARNINGS PROFILES

Discipline			Number of Years of Professional Experience					
			1	2-4	5-9	10-14	15-19	20+
PHYSICS								
	Bachelor	Age*	(22)	(23-25)	(26-30)	(31-35)	(36-40)	(41-65)
		Salary**	$ 7,400	$ 7,844	$ 9,768	$12,358	$13,320	$13,900
	Ph.D.	Age*	(28)	(29-31)	(32-36)	(37-41)	(42-46)	(47-65)
		Salary**	$10,600	$11,236	$13,992	$17,702	$19,080	$19,928
ZOOLOGY								
	Bachelor	Age	(22)	(23-25)	(26-30)	(31-35)	(36-40)	(41-65)
		Salary	$ 5,000	$ 5,200	$ 6,400	$ 7,650	$ 8,600	$ 9,800
	Ph.D.	Age	(29)	(30-32)	(33-37)	(38-42)	(43-47)	(48-65)
		Salary	$ 8,400	$ 8,736	$10,752	$12,852	$14,448	$16,464
SOCIOLOGY								
	Bachelor	Age	(22)	(23-25)	(26-30)	(31-35)	(36-40)	(41-65)
		Salary	$ 7,100	$ 7,668	$ 8,520	$ 9,656	$10,579	$11,857
	Ph.D.	Age	(29)	(30-32)	(33-37)	(38-42)	(43-47)	(48-65)
		Salary	$ 8,500	$ 9,180	$10,200	$11,560	$12,665	$14,195
ENGLISH								
	Bachelor	Age	(22)	(23-25)	(26-30)	(31-35)	(36-40)	(41-65)
		Salary	$ 6,300	$ 6,867	$ 7,749	$ 8,946	$ 9,702	$12,033
	Ph.D.	Age	(30)	(31-33)	(34-38)	(39-43)	(44-48)	(49-65)
		Salary	$ 7,500	$ 8,175	$ 9,225	$10,650	$11,550	$14,325

*Assumes Bachelor has one year of experience at age 22; Ph.D. has one year of experience at age 22+n (n = time required to earn a Ph.D.). Assumed starting salaries are derived from Table 16, 1964 National Register, "Median Annual Salaries of Full-Time Employed Civilian Scientists; By Field and Age."

**Salaries are projected by applying the salary growth indices (Table 13) to assumed starting salaries.

Becker's formula was modified somewhat to reflect the probability that a Ph.D. will continue to earn until age 65. For this, the salary differential of each year of the earnings period was adjusted with mortality statistics.* Thus the formula actually employed is as follows:

$$C = \sum_{1}^{n} \frac{k_j(P_m)}{(1+r)^j}$$

where:

P_m = the probability of surviving at least one year at age m.

m = the age which corresponds to year j in the earnings period

Basically, estimates of the internal rates of return for comparative purposes between disciplines as well as for alternative fields of employment within each discipline were developed with the same procedure.

THE FINDINGS

Different versions of the rates of return were calculated using different sets of values for k_j (i.e., the salary differential). The alternative sets of values for k_j are utilized by computational methods of varying degrees of sophistication. The different versions of rates of return for each discipline are shown on Table 15.

The least refined method of computation uses non-cross sectional data, i.e., the difference between median annual salaries of terminal Bachelors and Ph.D.'s irrespective of age and years of experience. This method is based on the assumption that the same median annual salary differential applies to terminal Bachelors and Ph.D.'s of all ages and years of experience and to each working year comprised by the post-Ph.D. earnings period. All rates of return computed with non-cross sectional data were calculated with the use of the following formula:

$$r = \frac{k}{C}$$

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*U.S. Department of Health, Education, and Welfare, Public Health Service National Office of Vital Statistics, "United States Life Table, 1949-1951," Vital Statistics Special Reports, XLI, No. 1 (November 23, 1954), pp. 10-11.

TABLE 15

RATES OF RETURN

Discipline	Internal Rates of Return Based on Cross Sectional Data				Internal Rates of Return Based on Non-Cross Sectional Data									
					All Professionals				Industry		Academic		Federal Government	
	Average Difference in Median Annual Salaries of Bachelors and Ph.D.'s	Present Value of Y_{ac} + Opportunity Cost	Internal Rates of Return* I	Internal Rates of Return** II	Assumed Number of Years of Post-Ph.D. Employment	Difference in Median Annual Salaries of Bachelors and Ph.D.'s	Present Value of Y_{ac} + Opportunity Cost	Internal Rates of Return III	Difference in Median Annual Salaries of Bachelors and Ph.D.'s	Internal Rate of Return IV	Difference in Median Annual Salaries of Bachelors and Ph.D.'s+	Internal Rate of Return V	Difference in Median Annual Salaries of Bachelors and Ph.D.'s	Internal Rates of Return VI
Physics	\$4,459	\$57,031	7.3%	5.2%	38	\$3,500	\$57,031	6.1%	\$5,200	9.1%	\$6,444	11.3%	\$3,800	6.7%
Physics Today++	\$3,880	\$57,031	6.1%	4.2%	38	--	\$57,031	--	\$3,143	5.5%	\$9,307	16.3%	\$ 705	0.1%
Zoology	\$4,860	\$41,623	11.5%	8.0%	37	\$3,500	\$41,623	8.4%	\$4,500	10.8%	\$6,933	16.6%	\$3,100	7.4%
Sociology	\$1,326	\$37,827	1.3%	0.9%	37	(-\$1,600)	\$37,827	(-4.2%)	***	***	***	***	***	***
English	\$ 839	\$29,172	0.2%	0.1%	36	\$3,700	\$29,172	12.7%	***	***	\$3,700	12.7%	***	***

*Rates of return based on cross sectional data and an average of the annual median salary differences occurring over the working life.

**Rates of return based on same data as (I) using the variable difference in median annual salaries of Bachelors and Ph.D.'s over the working life.

***Due to smallness of sample size for Bachelors by type of employment in the above cases, median annual salaries were presented for Ph.D.'s only in the 1964 National Register. This precluded the calculation of a salary differential and therefore a rate of return.

+Median annual salaries of Ph.D.'s in the sciences who are in academic employment were increased by two-ninths to allow for summer salaries.

++Two sets of rates of return by type of employment are presented for Physicists. The Physics Today rates are based on cross sectional data and the others are based on non-cross sectional data.

where

r = the rate of return

k = the difference in median annual salaries of Bachelors and Ph.D.'s in any year

C = total social cost of training a Ph.D. ,

The internal rates of return derived by means of this method are labeled set III on Table 15 and are presented for purposes of comparison with internal rates of return developed from more refined sets of salary data. Also, set III of the rates of return may be compared with the rates of return computed for alternative types of employment within each discipline, which by necessity had to be based on non-cross sectional salary differentials.

A somewhat more refined approach makes use of the earnings profiles which were described earlier. This method cumulates and averages the stream of annual salary differentials realized over the working life of the Ph.D., and assumes that k_j is constant over the doctorate's earnings period. The resulting internal rates of return are labeled set I on Table 15 and are based on a variation of Becker's formula:

$$C = \bar{k}_j \left(\frac{1 - \frac{1}{(1+r)^n}}{r} \right)$$

where:

C = total social cost of training a Ph.D.

$\bar{k}_j$ = average difference in median annual salaries of Bachelors and Ph.D.'s (mortality adjusted)

n = period of post-Ph.D. employment

r = the internal rate of return

The second approach just described suggests itself because it makes the computation of internal rates of return manageable without resort to data processing. However, with respect to utilization of the projected earnings profiles this method has its shortcomings. The main one of these is that as shown by the earnings profiles, the yearly salary differentials over working lives bear little resemblance to streams of uniform earnings differences. Salary differentials derived from the earnings profiles start out at a relatively low level and continue to grow over the working life. Thus, rates of return based on the above method have a consistent upward bias, because the discounting procedures by which estimated lifetime income differences are converted to present values attach more weight to income differentials realized early in life than to those realized later on.

The third and most refined approach utilizes the actual income differentials realized each year in the sequence in which they occur in the earnings profiles. This approach utilizes the derived salary differences with the greatest precision.* The resulting internal rates of return are labeled set II on Table 15.

The salary data for Physicists compiled in the *1964 Register* were published in greater detail and with more comprehensive cross-tabulations through the initiative of the *American Institute of Physics*.** This supplemental source of salary information on Physicists provides an opportunity to calculate rates of return for Physicists based on more refined data than the internal rates of return derived from the *1964 Register* data. The information published in *Physics Today* provides separate sets of cross sectional salary data by years of experience for terminal Bachelors and for Ph.D.'s in different types of employment. The strongest feature of the *Physics Today* article from our viewpoint lies in the fact that in presenting separate earnings profiles for terminal Bachelors and Ph.D.'s it throws some light on the hypothetical element inherent in our own profiles. The *Physics Today* earnings streams differ from those projected for this study in that they yield a smaller total lifetime and average annual income differential for the two groups under comparison. This difference makes for lower rates of return for Physicists in sets I and II when computed with *Physics Today* data than when computed with *1964 Register* data. Although the *Physics Today* rates of return are probably the most reliable of all the rates presented, it should not be generalized that more detailed salary data for the other disciplines would necessarily yield lower rates of return than those here presented. The direction of possible bias in rates of return for the other disciplines has yet to be determined.

One objective of the present study is to differentiate between rates of return to a Ph.D. in a given discipline by types of employment which avail themselves to the doctorate holder. The *1964 Register* provides data on median annual salaries of professionals by degree and type of employment such as: industry, academic, and federal government; however these salary statistics are not presented in cross sectional form. Though the rates of return by type of employment, derived from non-cross sectional data are of some use for intradisciplinary employment comparisons, the types of data utilized in calculating these rates do not facilitate a reliable measure of the absolute level for these rates of return. This becomes apparent in a comparison of rates of return based on cross sectional data with those based on non-cross sectional data (see Table 15). The rates of return to investment in Ph.D.'s by type of employment are derived by means of the same procedure as set III of the internal rates of return described earlier.

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*The only practical means of utilizing this approach is with the aid of a computer.

**Sylvia Barish, "Who Are Physicists? What Do They Do?" *Physics Today*, January, 1966, pp.70-76.

Before interpreting the rates of return set forth on Table 15, several of the deficiencies inherent in the calculations ought to be reviewed. One of these refers to the fact that all rates of return other than those based on *Physics Today* data are derived from so-called hypothetical earnings profiles for terminal Bachelors and Ph.D.'s based on a uniform index of income growth for both groups. The hypothetical earnings profiles are based on the assumption that years of experience yield the same rate of growth of salary to Bachelors and to Ph.D.'s. The *Physics Today* data do not entirely support this assumption but indicate that application of a uniform income growth index to both groups introduces an upward bias into the rates of return for Physicists. This leads one to suspect that the rates of return for the other disciplines may also be subject to some distortion. However, it does not follow that the distortion inherent in the rates of return for the other disciplines necessarily produces an upward bias, as it did in Physics. Conceivably the direction of the bias varies between disciplines.

Another shortcoming relates to the last, open-ended interval, in the *1964 Register* cross sectional salary statistics by years of experience, i.e., the interval of 20 or more years of experience. It is possible that years of experience during the late phase of working life, affect earnings of terminal Bachelors differently from those of Ph.D.'s. This is a possibility but the insufficiency of information of lifetime salary patterns precludes the formulation of assumptions about the direction of this differential effect.

Finally, the estimates contain the limitations of any results based on cross sectional data. Cross sectional data compiled in any given year are frequently used to construct earnings profiles. But lifetime earnings differences projected on the basis of these profiles may for a variety of reasons not truely represent the future salary growth of the two groups.* The income projections which underlie the rate of return estimates, are free from assumptions about the sharing of economic growth between terminal Bachelors and Ph.D.'s, and to the extent that future growth is not shared equally by these two groups, projections of the earnings differentials will be inaccurate.

Due to data limitations the intradisciplinary comparisons of internal rates of return by type of employment are restricted to two of the four disciplines. With respect to these two disciplines, Physics and Zoology, it

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*See Herman P. Miller, "Lifetime Income and Economic Growth," *The American Economic Review*, September, 1965, pp. 834-844.

should be noted that the highest rate of return to Ph.D.'s by type of employment does not correspond to employment with the highest salary level in the field. The highest rate of return is realized in the type of employment which reflects the largest net earnings differential between terminal Bachelors and Ph.D.'s, and this occurs in academic employment in both disciplines.

The internal rates of return by type of employment, although derived by means of the least refined calculation procedure, and with the crudest form of earnings data, show that in both Physics and Zoology, the investment yields on a Ph.D. are highest in academic employment, next highest in industry and lowest in the federal government. The *Physics Today* data make possible a calculation of rates of return by types of employment for Physicists, based on cross sectional data. These rates of return depict the same relationship among the three types of employment as the rates based on the *1964 Register* data, even though the more refined *Physics Today* data yield rates which are different in absolute values. These findings appear to indicate that relatively high salaries in industry and in the federal government can be achieved by means of inservice training and years of experience of the terminal Bachelor, with the result of a relatively small total salary differential between terminal Bachelors and Ph.D.'s. In comparison, a Ph.D. degree (for whatever reasons) seems to be a necessary condition for the attainment of relatively high salary levels in academic life.

DISCUSSION OF THE FINDINGS

Interpretation of the rates of return calculated in this study should be preceded by comparisons with previously calculated rates of return. Table 16 presents such rates as have been calculated for different levels of education. These rates may be summarized as follows:

(1) Even though there may be increasing rates of return over the initial years of schooling, the trend appears to be downward after completion of elementary education.

(2) The monetary return to society's total investment in each level of education, *as measured*, is smaller than the private rate of return, though it is commonly assumed that the social rate of return (if it could be properly measured) is probably higher than the private rate.

(3) When regarding trends of rates of return over time, the rates appear to have risen for high school graduates, while they have fluctuated for college graduates.

TABLE 16

COMPARATIVE RATES OF RETURN

Private Rates of Return			Social Rates of Return		
I. Elementary Education (8 yr)			I. Elementary Education (8 yr)		
Hansen:	infinite rate of return		Hansen:	15.0%	(1949)
II. High School (4 yr)			II. High School (4 yr)		
Hansen:	15.3%	(1949)	Hansen:	11.4%	(1949)
	14.7% (after tax)	(1949)			
Becker:	16%	(1939)			
	20%	(1949)			
	25%	(1956)			
	28%	(1958)			
III. College (4 yr)			III. College (4 yr)		
Hansen:	11.6%	(1949)	Hansen:	10.2%	(1949)
	10.1% (after tax)	(1949)			
Becker:	14.5%	(1939)	Becker:	13.0%	(1939)
	13.0%	(1949)		12.5%	(1949)
	12.4%	(1956)			
	14.3%	(1958)			
Hunt:	12.0%	(1947)			
IV. Physicians and Dentists			IV. Physicians and Dentists		
Hansen:	Physicians				
	13.5%	(1939)			
	13.4%	(1949)			
	12.8%	(1956)			
	Dentists				
	12.3%	(1939)			
	13.4%	(1949)			
	12.0%	(1956)			
V. Graduate Education (3-1/4 yr)			V. Graduate Education (3-1/4 yr)		
Hunt:	2.2% - 3.0%	(1947)			

Sources: W. Lee Hansen, "Total and Private Rates of Return to Investment in Schooling," *Journal of Political Economy*, April, 1963; Gary S. Becker, *Human Capital*, *op. cit.*; Shane J. Hunt, "Income Determinants for College Graduates and the Return to Educational Investment," *Yale University Economic Growth Center, Center Paper No. 34*, 1964; W. Lee Hansen, "Shortages and Investment in Health Manpower," *Proceedings of the Conference on the Economics of Health and Medical Care*, The University of Michigan, Ann Arbor, Michigan, 1964.

(4) Private rates of return for post-Bachelor education in the case of Physicians and Dentists exceed the rate of return to college education, though internal rates of return to both Physicians and Dentists were lower in 1956 than they were in 1939.

(5) The private internal rate of return calculated for 3-1/4 years of graduate education on the basis of 1947 earnings data is remarkably low relative to the private rate of return to investment in a college education.

In the context of previous rate of return estimates, the rates of return developed in this study seem to fit roughly into the general pattern of educational investment yields. Conceptually, the rates here reported correspond to Hansen's "total rates of return" and in view of the downward trend of the rates over successive levels of education, one would be inclined to predict lower yields to the investment in Ph.D.'s than corresponding yields for college graduates. In comparison to Hansen's 10.2% return to college education, the most reliable version of our rates for graduate education (set II) ranges from 0.1% - 8.0% for the four disciplines. However, the wide discrepancy between rates for Physics and Zoology on the one hand, and for Sociology and English on the other, calls for clarification.

We will now turn to a brief discussion of the data, the computation procedures, the underlying assumptions and necessary qualifications. An attempt will be made to assess the source and direction of possible biases, and to make explicit all the assumptions which are implied by the presented rate of return estimates.

The validity of the estimates must be considered with respect to validity of the data and calculation procedures. First, I will specify those factors which are relevant to but nevertheless omitted from the rate of return analysis. Next I will examine what rates of return can measure given the availability of ideal data. And finally the presented results will be evaluated, partly in relation to a set of explicitly stated value judgments.

One of the most serious shortcomings of the findings presented in this chapter results from the very fundamental assumption that differentials in monetary earnings of individuals adequately express the differential effect of respective individuals on national income. Although it is reasonable to expect a certain amount of correlation between relative contributions to society and relative monetary rewards there are several areas of discrepancy between these two factors that may be outlined. The two major sources of this divergence constitute the presence of psychic or non-pecuniary income and the existence of so-called neighborhood effects or externalities. Psychic income and monetary income appear to be inversely related in competitive labor markets because whenever non-pecuniary income varies between occupations or between different levels of work within an occupation compensating variation would enter into the pattern of money incomes. It is generally argued that the psychic income which Ph.D.'s derive from their work is extremely high and relates to such factors as challenging work, social purpose, freedom, and security of employment. Even when labor markets are perfect, individuals may willingly work for monetary compensation below their marginal productivity, because the sum of psychic and monetary income, rather than monetary income alone, is the object of maximizing behavior. Clearly psychic income must be considered a return on educational investment both on the private and on the social level. The rates of return here presented are of limited meaning even in a relative sense unless it can be assumed that psychic income is realized in equal magnitude by Ph.D.'s in the four disciplines. At present this type of an assumption is deplete of a factual basis as psychic income has remained in the category of the unmeasurables. Granted that there is no simple method of measuring psychic income directly, the desire for further refinement of the rate of return analysis should create incentive for developing indirect estimates of relative psychic incomes associated with types and levels of education.

Moreover, existence of discrepancies between the value of an individual's contribution to direct private output and the value of his total and partly indirect contribution to national income further weakens the assumption that a man's income effectively measures his contribution to society. If the hiring of individuals with educational degrees is motivated primarily by conspicuous consumption of the employer, the earnings of such individuals may overestimate their productivity. More commonly it is assumed however, that earnings of Ph.D.'s are likely to understate their contribution to society.* Presumably Ph.D.'s are not fully compensated for the by-products of their contribution to the advancement and diffusion of knowledge. The rate of return estimates of this study are here presented as social rates of return because they are calculated with respect to before-tax earnings differentials, and tax payments are considered to partially reflect the indirect contribution of individuals to society. Becker refers to such estimates as first approximations to social returns and proceeds to develop upper limits for social returns

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*"... the individuals engaged in advancing knowledge acquire skills and perspectives that greatly transcend the sum of the information appearing in their publications. The contribution of a Fermi or a Von Neumann to our society is far greater than that of the bound volumes of their collected works or even than their influence on their students. A great scientist becomes a teacher of his whole culture. The people who devote most of their lives to research become a national human resource, available in emergencies to turn their attention to many problems outside their own immediate fields of interest."
Harvey Brooks, "Future Needs for the Support of Basic Research," in Basic Research and National Goals. A Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences, March 1965, pp. 91-92.

by attributing all of the residual factor in economic growth, which Denison calls "advancement in knowledge," to education.*

Since this study focuses on relative rates of return to graduate education in four disciplines, no attempt was made to adjust the social rates of return for indirect contributions which presumably are made by Ph.D.'s to the advancement in knowledge. Indirect returns to date have also remained in the category of unmeasurables, and it is therefore difficult to distribute shares in the general advancement of knowledge, first between individuals with Bachelor and Doctoral degrees and secondly between Ph.D.'s in different disciplines. Whether a method for allocating these shares will be developed in the future remains to be seen.

Having acknowledged the existence of two important unmeasurables, a question arises as to what rates of return are capable of measuring given the availability of perfect data on measurable factors. Under certain conditions internal social rates of return can measure the relative monetary value which the market places on different types and levels of education, as derived from relative money values attached to particular productive services, for which the education is a prerequisite. The conditions mentioned above include the following: first, that a given level or type of education is always required for and utilized in the productive services performed by the person who embodies the education. It is not reasonable to expect that the earnings of an individual who has a Ph.D. degree in Chemistry and who is employed as a cook, will reflect the market value of his graduate education in Chemistry. Secondly, the condition that the earnings differentials on which the rates of return are based refer to two groups, identical in intelligence, motivation, length of the workweek, etc., who are in the same profession and differ only in one respect, namely that one has a Bachelor degree, 0 years of post-Bachelor formal education, and 0 or X years of on the job training, and the other has a Ph.D. degree, 0 years of post-doctoral education, and the same number of years of on the job training as the Bachelor. In the absence of detailed knowledge about the data used it is conceivable that X, an English major with a B.A. degree, takes a job which entails productive services that are in no way comparable to the productive services performed by Y, who has a Ph.D. degree in English and a job totally different from that of X. If the earnings differentials used in the calculations are based on X's and Y's the rates of return will be distorted. And thirdly, the condition that labor markets in which the earnings differentials are determined are perfectly competitive.

The current form and nature of earnings data do not make possible the derivation of salary differentials of two carefully circumscribed groups differing only in amounts of formal, educational attainment. However, in view of the forever increasing demand for knowledge about knowledge, the chances are good that a sizable amount of effort will be devoted to development of better data on salaries and salary patterns relative to education.

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*Gary S. Becker, op. cit., pp. 118-119.

Finally, I will turn to the major biases believed to be inherent in the rate of return estimates, and suggest my own impression of the directions and magnitudes of these biases. In my opinion there are two types of features making for upward and four making for downward bias. On the assumption that on the average individuals with Ph.D. degrees are more intelligent, more highly motivated, have more stamina and greater social endowment, than terminal Bachelors on the average, the rates of return have an upward bias. This bias is apt to be relatively small.* If Ph.D.'s in the four disciplines work more hours per week than do terminal Bachelors in same disciplines (the faculty workweek data indicate an average of 54-56 hours per week for those in academic employment) the rates are biased in the upward direction. Even without workweek data on terminal Bachelors I am willing to assume that such a differential in workweek may exist but its magnitude is probably quite moderate. The factors which make for downward biases include (a) the unmeasured external effects, (b) the unmeasured psychic incomes, (c) the lack of information on in-service training of terminal Bachelors and on the substitutability between formal graduate training and in-service training, and (d) possible lack of comparability between groups on which the earnings differentials are based. It is my impression that (a), (b), and (c) are responsible for relatively large downward biases in the rates of return whereas (d) may introduce a bias of moderate size. In summary, there are two features making for moderate upward biases and four features making for relatively large downward biases and therefore, it is more than likely that the rates here presented significantly underestimate the investment yields to society which result from graduate education.

Finally it should be mentioned that the rates of return for Sociology and English are particularly tenuous because the salary data underlying the returns for those disciplines call for special qualification. Salary data for the above two disciplines are based on much smaller samples than those of the natural Sciences and also relative to Physicists and Zoologists a much higher percentage of professionals in Sociology and English enter the low-salaried teaching profession. The average difference in median annual salaries of Bachelors and Ph.D.'s in Sociology and English, as shown on Table 15 is considerably below that for Physicists and Zoologists. However, it cannot be stated conclusively whether or not the above-mentioned factors completely account for the sizable difference in rates of return to graduate education between the natural Sciences and Sociology and English.

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*Shane Hunt found that rates of return to graduate education, when controlled for other income determinants, changed very little, Shane J. Hunt, op. cit., p. 354.

CHAPTER VII

SUMMARY AND IMPLICATIONS

During the last two decades, our society has developed mounting awareness of the fact that its position in world leadership as well as its cultural, economic, technological, and other achievements are increasingly dependent on highly trained manpower and on the encouragement of science and basic research. This awareness has been reflected in a continuously growing demand and heightened competition for individuals with high levels of educational attainment as well as in steady growth of the proportion of resources allocated to research and other forms of knowledge production. Considerable attention has recently been focused on the subject of scientific and highly specialized manpower and on the educational setting in which the highly demanded skills are developed. In this context universities have become recognized as major establishments in the production and distribution of knowledge by way of training and employing teachers, researchers, and professionals.

Widespread recognition of the crucial importance of the knowledge industry and of the high-level manpower base on which its continued expansion depends has brought into focus the inordinate lack of information on one of the major enterprises in knowledge production, the graduate school. While projections of graduate student enrollments suggest a rate of future expansion which exceeds that for undergraduate enrollments,* and while there is no doubt about the growing volume of aggregate expenditures on graduate education, and no hesitance on the part of undergraduate institutions to continuously add to the number of existing programs at the master's and doctoral level, there is less information about graduate education than about most other aspects of the educational system. Statistics on numbers and distribution of currently enrolled graduate students, and on numbers and distribution of graduate degrees awarded appear with an excessive time lag, while the former do not adequately cover such details as the distinction between full-time and part-time students; information on capacity for expansion of existing graduate programs, with respect to physical facilities and availability of graduate faculty is very scarce, and even information on the volume of financial support and university, part-time employment opportunities available for graduate students is extremely limited.**

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*Allan M. Cartter and Robert Farrell, "Higher Education in the Last Third of the Century," The Educational Record, Spring 1965, p. 124.

**Such studies as John L. Chase's Doctoral Study, Fellowships and Capacity of Graduate Schools, U.S. Office of Education, Washington, 1961, and J. A. Davis, Stipends and Spouses, University of Chicago Press, 1962, are important contributions but are by now largely outdated.

Although there have been recent and notable improvements in the availability of factual and relatively up-to-date type of information on graduate programs, it is likely that further advancement in this direction would considerably enhance progress in substantive studies on the problems related to expansion of graduate education. Within the last few years there has been a notable response to the need for information and research on graduate education in the form of such studies as: Bernard Berelson's comprehensive survey on *Graduate Education in the United States*[*]; Allan Tucker's *Attrition of Graduate Students at the Ph.D. Level*[**]; Kenneth M. Wilson's *Of Time and the Doctorate*[***]; *Doctorate Production in United States Universities, 1920-1962* and *Profiles of Ph.D.'s in the Sciences*, both by Lindsey R. Harmon[****]; *The Education and Training of America's Scientists and Engineers*, by Seymour Warkow and John Marsh[+]; and *An Assessment of Quality in Graduate Education*, by Allan M. Cartter.[++] All of these inquiries relate to some aspect of the study here reported on the costs and returns of doctoral programs in four disciplines.

Relative to the paucity of descriptive, reportable facts on graduate education even less is known about the ranges and trends of costs which apply to graduate education in general, and about the relative training costs in different disciplines. Though it is generally agreed that graduate education is costly, there are few empirical studies, if any, on the level and variability of the costs. One of the more specific statements on costs reads as follows:

> "Graduate education is, of course, the most expensive level of education; it is even higher than medical education. In a recent survey the University of Michigan found that the ratio of freshman/sophomore to junior/senior to graduate education was 1:3:8. The actual cost of graduate education may run from a minimum of about $4,000 per student per year up to as much as $12,000 per year in some institutions."[+++]

With respect to different study areas it is stated in a Report of the President's Science Advisory Committee[++++]:

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[*] New York, McGraw-Hill Book Co., 1960.

[**] Office of Research Development and the Graduate School, Michigan State University, 1964.

[***] Southern Regional Education Board, Atlanta, Georgia, 1965.

[****] National Academy of Sciences—National Research Council, 1963 and 1965.

[+] National Opinion Research Center, Chicago, 1965.

[++] American Council on Education, Washington, 1966.

[+++] C. C. Furnas and Raymond Ewell "The Role of Research in the Economics of Universities," in *Financing Higher Education 1960-1970*, edited by Dexter M. Keezer, McGraw-Hill Book Company, Inc., 1959, p. 97.

[++++] *Meeting Manpower Needs in Science and Technology*, A Report of the President's Science Advisory Committee, The White House, Washington, 1962, p. 34.

"The best available information on true costs to the universities for graduate education comes from figures submitted by them in connection with grants under NDEA Title IV. These figures, which are undoubtedly imcomplete, are:

	Average Annual True Costs Per Fellow (as documented)
Humanities	$3,200
Education	3,300
Social Sciences	3,250
Biological Sciences	3,374
Physical Sciences and Mathematics	3,380
Engineering	4,020

Not much detail is known about the factual basis of the above figures yet these two citations pretty nearly summarize knowledge about costs of graduate education at the time of conception of this study.

At the very beginning of this report mention was made of the exploratory nature of this study. Whatever cost calculations on doctoral programs might have existed at the time when this study began, were developed in an assortment of unrelated and incomparable studies based on concepts and definitions peculiar to individual institutions, each of which engaged in cost analysis primarily for internal purposes. Thus confronted with a lack of uniform cost data this study was designed with the objective of developing a single set of definitions, concepts, and measurement tools, to be applied uniformly to cost analyses of four Ph.D. programs in all participating universities. However, there was no guarantee at the outset of the project that the intended cost analyses would be feasible. The question of feasibility entails two separate aspects: one having to do with information-gathering problems, the other with measurement problems. More specifically, the feasibleness of analyzing costs of doctoral programs comprises the following questions:

(a) Do all the needed records exist in the appropriate form, are they retrievable and can required information on which there are no records be compiled at each institution?

(b) Can all factors or inputs utilized in graduate training programs be identified, separated from other programs with which they are used jointly and are all the crucial variables measurable on the basis of available information?

Ways were found to cope with problems in both the above areas, so that it became practicable to develop estimates on the training costs of Ph.D.'s presented in earlier chapters. The problems of type (a) which were encountered have already been described in Chapter II. Universities with varying reputations for general quality of financial records were included in the sample but these so-called reputations were only of limited aid in identifying conduciveness (or the lack thereof) for the proposed analysis. Certainly there was substantial variability between institutions regarding the availability and quality of pertinent data. However, the institutions's reputed performance in the area of general financial analysis for internal purposes was not always indicative of its suitability for the type of analysis here conducted. Moreover, in some institutions the bulk of the data were gathered at the departmental rather than at the institutional level, and there is almost as much variation in record-keeping practices between different departments of the same university as there is between different universities.

On the whole, there is much scope for improvement by graduate schools and graduate departments in areas of quality and precision of data collection, classification, and retention. Such studies as the one recently completed by John E. Swanson and his co-workers on Financial Analysis of Current Operations of Colleges and Universities,* create a basis for hope that in the future universities may adopt a single set of agreed-upon principles, classifications and ground rules which would assure a uniform and common base for cost analyses. While the present study could be conducted with much greater speed and efficiency, if the above becomes an actuality, the accuracy and reliability of resulting cost estimates would also be substantially improved.

Even more complex than the problems of information-gathering nature are those having to do with measurability of the "output" or "product" of doctoral programs and the allocation of inputs between several functions or operations for which they are jointly utilized. These problems have also been treated in earlier chapters. The tools and techniques which were developed to cope with such problems represent exploratory and preliminary attempts at quantifying variables that are not easily subjected to measurement. For example, the product of graduate instruction and graduate research training was measured in terms of student credit hours and effort or output of graduate faculty was measured in terms of hours devoted to each professional activity. Future studies may improve the measuring devices here applied or may develop new and superior ones. However, the cost estimates presented in this report are solid in the sense that all tools and methods were employed with maximum care and precision, utilizing every minutia of information pertinent to the analysis. A study such as the one here reported, would gain a lot in reliability when conducted on a longitudinal base; within its present scope the study yields estimates that are essentially first approximations, and as such they are trustworthy.

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*John E. Swanson, Weseley Arden, Homer E. Still, Jr., Financial Analysis of Current Operations of Colleges and Universities. The University of Michigan, Ann Arbor, Michigan, 1966.

The predicted expansion in future graduate enrollments places new emphasis on the need for data on graduate training costs, as it gives rise to questions such as the following: to what extent can existing graduate departments absorb additional graduate students; what is the relationship between training costs per student (per year) and the number of graduate students enrolled in a department; and what is the cost of setting up new doctoral programs in given disciplines. If the per student cost curve for graduate education is U shaped it is perhaps reasonable to argue that existing departments should absorb additional students until the bottom of the curve is reached; at that point the rising average cost in older departments must be compared with the per student cost in new departments, and must be viewed in the context of predicted volumes of future enrollments.

However, expansion in enrollments should be related to its effects on both cost and quality of doctoral programs. Economies of scale are desirable, but only when the effectiveness of a department's graduate program is not thereby impaired. The qualitative factor becomes extremely important when capacity is examined from the viewpoint of accessibility of graduate faculty. Graduate student supervision is crucial during the latter phases of graduate study, and a department which can physically accommodate a larger volume of students through enlargement of class sizes, may encounter bottlenecks as far as faculty time for student supervision is concerned.

The problem of graduate departmental capacity in relation to cost is a difficult one to analyze. Because of the heterogeneity of graduate programs the per student cost of training is a function of numerous variables other than the number of students enrolled. This has been shown to a certain extent in the statistical analyses presented in Chapter V. Also, an analysis of the unused capacity of graduate departments must take into account the distribution of enrolled graduate students with respect to level of graduate study. A graduate department whose enrollment is concentrated in terminal master's degree candidates can probably handle more students than one with similar resources but whose enrollment consists largely of doctoral candidates. It was mentioned earlier that information on distribution of enrolled graduate students by level was usually not available at surveyed institutions. In view of the remarkable variability among graduate programs in the same discipline, the number of observations included in this survey (11 in each discipline) is too small to permit generalizations about the relationship between cost, size, and capacity.

Being much more familiar with the origin, nature and precision of the data underlying the cost estimates than with the salary data underlying the rates of return, I rank the reliability of findings on average costs above the reliability of the rates of return. Chapter VI contains a detailed account of deficiencies of the salary data and of the qualifications which must accompany the rate of return estimates. Nevertheless, in order to examine some possible implications suggested by the estimates it is permissible to assume for a moment that at least in a relative sense the rates of return are accurate.

The most reliable rates (set II on Table 15) indicate that the return is highest for Zoology - 8.0%; next highest for Physics - 4-5%; much lower in Sociology - .9%, and lowest for English - .1%. This could imply that, on strictly economic grounds, and optimal distribution of society's fellowship funds calls for subsidization of graduate students in the natural sciences, and termination of subsidies to graduate students in Sociology and English. On the assumption that the distribution of fellowship funds among disciplines influences the distribution of Ph.D. output among disciplines one may argue that by restricting fellowships to high rate of return disciplines society may tend to ultimately bring the rates of return into equilibrium. If the absence of fellowship support to English and Sociology in fact results in a smaller supply of Ph.D.'s in those disciplines in the long run, and if the demand for Ph.D.'s in respective disciplines remains constant the earnings differentials between Bachelors and Ph.D.'s and subsequently the social and private rates of return should rise, thus ultimately benefiting English and Sociology Ph.D.'s by way of higher salary potentials.

On the other hand, if one advocates continued subsidization of graduate students in Sociology and English, this could be based on either or both of the following assumptions: that psychic incomes of Ph.D.'s in English and Sociology are considerably higher than those realized by Physicists and Zoologists, or that the excess of marginal productivity over the salary of Ph.D.'s is considerably larger in the former two disciplines than it is in the latter two. The first assumption does not appear to have much validity but the second one sounds somewhat plausible in that Ph.D.'s in English and Sociology have relatively fewer nonacademic employment opportunities than do the natural scientists, and the teaching profession is notable as one in which salaries understate marginal productivities. According to the 1964 National Register, the percentage of professionals employed by educational institutions is 43% in Physics, 58% in Biological Sciences, 77% in Sociology, and 69% in Linguistics. These figures however, cover all professionals in the discipline and are not restricted to Ph.D.'s alone. Hence, the relative differences in percentages of Ph.D.'s employed by educational institutions in respective disciplines may be even larger.

The actual allocation of society's fellowship funds between the four disciplines is shown for 1959-60 on Table 17. Although the distribution of fellowship funds may have undergone change between 1959-60 and 1964-65 these data indicate that irrespective of the source of fellowship funds (university, government, or noninstitutional-nongovernment) Physics and English rank among the six fields receiving largest volumes of support, whereas Sociology and Zoology usually rank below the twelve most highly endowed fields. English receives more total support than Physics in the form of university tuition and noninstitutional-nongovernment fellowships, while Physics receives more support than English in the form of other university and government fellowships. Sociology receives more total fellowship support than Zoology from all sources except government fellowships. Thus all fellowship donors except the government allocate the smallest volume of funds to Zoology, which shows the highest rate of return to investment in Ph.D.'s.

The average size of fellowships awarded to graduate students in the four disciplines is also subject to variability. Graduate students in Physics on the average receive larger fellowships than graduate students in English, though the size of the difference in average fellowships varies with the fellowship source. In the category of university tuition and noninstitutional-nongovernment fellowships, the average fellowship size is smallest for Zoology, relative to the other three disciplines, and in the category of other university and government fellowships the average fellowship size is smallest for English. Graduate students in Physics consistently receive larger fellowships than graduate students in the other three disciplines.

The presented information suggests that the distribution of total fellowship support among the four disciplines is governed to a certain extent by the distribution of graduate enrollment and doctorate production among different disciplines. When relating % of total dollar fellowship support allocated to each field in 1959-60 to the % of total doctorates awarded in each field in 1958-59, in Physics and English the % of total fellowship support received exceeds the % of total doctorates awarded, whereas in Sociology and Zoology the % of total fellowship money received is about equal to the % of total doctorates produced. This may be interpreted as

Discipline	Percent of Total Dollar Fellowship Support by Field (1959-60)	Percent of All Doctorates Awarded by Field (1958-59)
Physics	7.3	5.1
English	5.5	4.1
Sociology	1.7	1.7
Zoology	1.6	1.5

Source: Doctoral Study, op. cit. Table 9, p. 18.

TABLE 17

FELLOWSHIP SUPPORT RANKED AMONG THE FOUR DISCIPLINES (1959-1960)

	Physics	Zoology	Sociology	English
Annual Doctorates Awarded (1958-59)	482	144	157	497
University Tuition Fellowships				
Rank number in order of total $ support	3	28	12	2
Number of fellowships	390	96	136	480
Average size of fellowships	$ 658	$ 336	$ 651	$ 550
Other University Fellowships				
Rank number in order of total $ support	3	22	20	4
Number of fellowships	381	136	161	584
Average size of fellowships	$2,812	$1,916	$1,694	$1,450
Government Fellowships				
Rank number in order of total $ support	1	8	20	6
Number of fellowships	376	94	50	164
Average size of fellowships	$2,564	$2,413	$2,346	$1,628
Noninstitutional-Nongovernment Fellowships				
Rank number in order of total $ support	6	35	13	1
Number of fellowships	118	16	49	249
Average size of fellowships	$2,276	$1,902	$2,211	$2,149

Source: John L. Chase, Doctoral Study, op. cit.: Tables 1, 3, 6, 7, and 11.

follows: an attempt is made to attract a growing number of potential Ph.D.'s into one relatively high rate of return field—Physics and into one low rate of return field—English, whereas no attempt is made by way of fellowship support to either increase or decrease the relative size of potential doctorates in Sociology and Zoology. Whether one judges this to be an efficient or inefficient allocation of fellowship funds would depend largely on one's estimation of the relative magnitudes of unmeasured external contributions made by Ph.D.'s in the four disciplines, and on the relative future demands anticipated for Ph.D.'s in each of the four disciplines. It should be noted also that a given distribution of fellowship resources, even when considered inefficient on economic grounds, could be perfectly rational when noneconomic values are given predominant consideration.

Aside from a possible reallocation of society's fellowship funds the findings here presented suggest one alternative approach to the raising of investment yields on English and Sociology Ph.D.'s. There probably is scope for some reduction in graduate training costs in these two disciplines because the average number of years spent on obtaining the doctorate is high relative to the natural sciences. Therefore, if English and Sociology doctoral programs could be accelerated (without simultaneous reduction in quality of respective programs), so as to reduce the number of years during which students forego income, opportunity costs and therefore the total social costs will go down, and if salary patterns remain the same, the rates of return will rise. However, the cost of training Ph.D.'s in English and Sociology when decreased by means of acceleration of doctoral programs, will probably not go down more than $4,000-$7,000. Although the above will serve to narrow the differentials between rates of return of the Natural Sciences and those of English and Sociology to a certain degree, this adjustment by itself is not likely to bring the rates of return into equilibrium.

APPENDIX

GRADUATE FACULTY WORK LOAD

RANK____________________ NAME____________________

Indicate below the number of hours of total weekly worktime spent on the following types of activities: (View this as an average weekly time distribution which applies to an academic year).

	No. of hrs. per week
I. Instruction - (Class time, class preparation, grading, etc.)	
A. Graduate Instruction	
B. Undergraduate Instruction	
II. Research	
A. Time spent on research not compensated with sponsored or special research funds	
B. Time spent on research compensated with sponsored or special research funds	
III. Administrative Duties	
A. Departmental Administration	
B. General University Administration	
IV. Time spent on supervision of research and/or dissertation of graduate students	
A. How many doctoral students do you currently supervise? __________	
B. What do you consider an ideal number of doctoral students to work under your supervision?__________	
V. Any other professional activity that makes regular demands on your worktime?__________	
Describe:__________	
VI. Total number of hours of work per week (on the average)	

Note: The sum of your answers to I-V should correspond to your answer to VI.

TABLE 18

SUMMARY OF COMPONENTS OF Y_{ac}: FOUR DISCIPLINES

(a) Physics

Universities		Non-Research Costs per Semester Hour					Research Costs per Semester Hour					Supplemental Costs per Semester Hour									
	Department Graduate Enrollment / Size of Faculty (1)	Teaching (faculty salary) (2)	Space (classroom rental) (3)	Total (4)	Number of Non-Research Semester Hr in "Representative Curriculum" (5)	Non-Research Cost of Training a Ph.D. (6)	Research Activity (salaries & equipment) (7)	Space (laboratory & student office) (8)	Total (9)	Number of Research Semester Hr in Ph.D. "Representative Curriculum" (10)	Research Cost of Training a Ph.D. (11)	Administrative (salaries, faculty salaries, supplies) (12)	Library (13)	Departmental (supplies, clerical) (14)	Fellowship (15)	Staff Benefits (16)	Faculty Office Costs (17)	Total (18)	Number of Total Semester Hr in Ph.D. "Representative Curriculum" (19)	Supplemental Cost of Training a Ph.D. (20)	Total Cost of Training a Ph.D. (21)
A	91/19	$20.31	$0.50	$20.81	53.5	$1,113	$ 726	$ 43.60	$ 770	38.8	$29,876	$15.66	$ 7.66	$52.99	$20.42	$ 9.73	$2 72	$109	92.3	$10,061	$41,050
B	65/14	16.72	0.27	16.99	52.3	889	737	14.20	751	31.1	23,356	21.72	18.39	18.07	26.03	9.42	1.08	95	83.4	7,923	32,168
C	63/12	18.77	0.94	19.71	43.0	848	454	134.65	589	14.8	8,717	19.81	21.05	15.21	13.13	8.52	4.16	82	57.8	4,740	14,305
D	101/25	20.81	0.90	21.71	51.2	1,112	2,209	159.52	2,369	16.7	39,562	34.16	10.79	12.93	11.26	8.71	4.30	82	67.9	5,569	46,243
E	75/15	15.69	0.64	16.33	79.5	1,298	2,161	74.62	2,236	34.7	77,589	8.42	11.32	9.82	7.43	8.32	2.06	48	114.2	5,482	84,369
F	336/39	7.20	0.42	7.62	61.8	471	244	25.31	269	81.8	22,004	6.98	8.18	18.87	9.83	4.60	0.78	49	143.6	7,036	29,511
G	113/17	12.45	0.57	13.02	54.0	703	512	82.50	594	37.4	22,216	30.04	12.72	11.50	7.19	9.82	1.83	73	91.4	6,672	29,591
H	100/13	12.75	0.90	13.65	48.0	655	933	108.66	1,042	26.7	27,821	26.41	20.43	62.95	39.98	8.70	4.29	163	74.7	12,176	40,652
I	199/23	11.38	0.84	12.22	46.7	571	599	88.35	687	33.3	22,877	34.44	40.96	19.18	22.28	16.83	2.10	136	80.0	10,8	34,322
J	155/28	14.00	0.55	14.55	61.8	899	842	92.87	935	11.4	10,659	12.60	7.53	14.56	8.07	8.98	2.80	55	73.2	4,026	15,584
K	170/30	10.74	0.88	11.62	47.2	548	392	48.17	440	64.6	28,424	18.75	13.36	34.35	6.98	8.08	3.21	85	111.8	9,503	38,475
Avg.	133/	$14.62	$0.67	$15.29	54.4	$ 835	$ 892	$ 79.31	$ 971	35.6	$28,464	$20.82	$15.67	$24.58	$15.69	$ 9.25	$2.67	$ 89	90.0	$ 7,700	$36,934
Public																					
A	91/19	$20.31	$0.50	$20.81	53.5	$1,113	$ 726	$ 43.60	$ 770	38.8	$29,876	$15.66	$ 7.66	$52.99	$20.42	$ 9.73	$2.72	$109	92.3	$10,061	$41,050
D	101/25	20.81	0.90	21.71	51.2	1,112	2,209	159.52	2,369	16.7	39,562	34.16	10.79	12.93	11.26	8.71	4.30	82	67.9	5,569	46,243
E	75/15	15.69	0.64	16.33	79.5	1,298	2,161	74.62	2,236	34.7	77,589	8.42	11.32	9.82	7.43	8.32	2.06	48	114.2	5,482	84,369
F	336/39	7.20	0.42	7.62	61.8	471	244	25.31	269	81.8	22,004	6.98	8.18	18.87	9.83	4.60	0.78	49	143.6	7,036	29,511
G	113/17	12.45	0.57	13.02	54.0	703	512	82.50	594	37.4	22,216	30.04	12.72	11.50	7.19	9.82	1.83	73	91.4	6,672	29,591
J	155/28	14.00	0.55	14.55	61.8	899	842	92.87	935	11.4	10,659	12.60	7.53	14.56	8.07	8.98	2.80	55	73.2	4,026	15,584
K	170/30	10.74	0.88	11.62	47.2	548	392	48.17	440	64.6	28,424	18.75	13.36	34.35	6.98	8.08	3.21	85	111.8	9,503	38,475
Avg.	149/	$14.46	$0.64	$15.00	58.4	$ 878	$1,012	$ 75.23	$1,088	40.8	$32,904	$18.09	$10.22	$22.15	$10.17	$ 8.32	$2.53	$ 72	99.1	$ 6,901	$40,683
Private																					
B	65/14	$16.72	$0.27	$16.99	52.3	$ 899	$ 737	$ 14.20	$ 751	31.1	$23,356	$21.72	$18.39	$18.07	$26.03	$ 9.42	$1.08	$ 95	83.4	$ 7,923	$32,168
C	63/12	18.77	0.94	19.71	43.0	848	454	134.65	589	14.8	8,717	19.81	21.05	15.21	13.13	8.52	4.16	82	57.8	4,740	14,305
H	100/13	12.75	0.90	13.65	48.0	655	933	108.66	1,042	26.7	27,821	26.41	20.43	62.95	39.98	8.70	4.29	163	74.7	12,176	40,652
I	199/23	11.38	0.84	12.22	46.7	571	599	88.35	687	33.3	22,877	34.44	40.96	19.18	22.28	16.83	2.10	136	80.0	10,880	34,322
Avg.	107/	$14.91	$0.74	$16.00	47.5	$ 741	$ 681	$ 86.47	$ 767	26.5	$20,693	$25.60	$25.21	$28.85	$25.36	$10.87	$2.91	$119	73.9	$ 8,918	$30,350

TABLE 18 (Continued)

(b) Zoology

Universities	Department Graduate Enrollment / Size of Faculty	Non-Research Costs per Semester Hour			Number of Non-Research Semester Hr in "Representative Curriculum"	Non-Research Cost of Training a Ph.D.	Research Costs per Semester Hour			Number of Research Semester Hr in Ph.D. "Representative Curriculum"	Research Cost of Training a Ph.D.	Supplemental Costs per Semester Hour							Number of Total Semester Hr in Ph.D. "Representative Curriculum"	Supplemental Cost of Training a Ph.D.	Total Cost of Training a Ph.D.
		Teaching (faculty salary)	Space (classroom rental)	Total			Research Activity (salaries & equipment)	Space (laboratory & student office)	Total			Administrative (salaries, faculty salaries, supplies)	Library	Departmental (supplies, clerical)	Fellowship	Staff Benefits	Faculty Office Costs	Total			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
A	80/22	$18.77	$0.50	$19.27	65.5	$1,262	$ 688	$ 60.10	$ 748	44.4	$33,211	$17.28	$ 6.60	$15.57	$20.08	$11.82	$3.14	$ 74	109.9	$ 8,132	$42,605
B	49/9	86.00	0.27	86.27	56.5	4,874	757	27.27	784	42.2	33,084	72.06	54.72	50.42	94.66	28.51	2.74	303	98.7	29,906	67,864
C	67/28	11.41	0.94	12.35	52.2	645	626	90.62	717	29.5	21,151	18.95	8.03	2.31	12.34	7.43	3.45	53	81.7	4,304	26,126
D	57/15	10.25	0.90	11.15	60.3	672	562	151.41	713	23.2	16,542	16.28	6.59	8.64	18.01	5.44	2.79	58	83.5	4,843	22,057
E	43/11	7.90	0.64	8.54	84.5	722	687	79.11	766	43.4	33,244	5.61	4.26	6.69	2.24	4.31	1.01	24	127.9	3,070	37,036
F	85/21	10.00	0.42	10.42	71.4	744	158	13.88	172	67.6	11,627	11.81	6.25	3.60	10.34	7.52	1.28	41	139.0	5,699	18,070
G	57/15	4.13	0.57	4.70	68.2	321	381	58.65	440	38.0	16,720	12.96	6.39	.97	.34	4.30	.93	26	106.2	2,761	19,802
H	68/18	13.79	0.90	14.67	40.3	591	692	78.08	770	48.2	37,114	29.73	14.95	24.48	48.50	12.85	6.40	137	88.5	12,125	49,830
I	43/11	17.85	0.60	18.45	41.9	773	521	30.26	551	39.9	21,985	32.21	33.53	26.19	50.60	20.22	2.70	165	81.8	13,497	36,255
J	60/12	33.68	0.55	34.23	68.5	2,345	521	168.57	590	14.0	8,260	49.90	12.48	19.84	45.42	19.12	5.98	153	82.5	12,623	23,228
K	52/15	8.37	0.88	9.25	63.3	586	135	22.29	157	65.0	10,205	7.50	4.38	3.42	10.01	4.12	1.66	31	128.3	3,987	14,768
Avg.	60/	$20.20	$0.65	$20.85	61.1	$1,221	$ 521	$ 70.93	$ 583	41.4	$22,103	$24.94	$14.38	$14.74	$28.41	$11.42	$2.92	$ 97	102.5	$ 9,177	$32,511
Public																					
A	80/22	$18.77	$0.50	$19.27	65.5	$1,262	$ 688	$ 60.10	$ 748	44.4	$33,211	$17.28	$ 6.60	$15.57	$20.08	$11.82	$3.14	$ 74	109.9	$ 8,132	$42,605
D	57/15	10.25	0.90	11.15	60.3	672	562	151.41	713	23.2	16,542	16.28	6.59	8.64	18.01	5.44	2.79	58	83.5	4,843	22,057
E	43/11	7.90	0.64	8.54	84.5	722	687	79.11	766	43.4	33,244	5.61	4.26	6.69	2.24	4.31	1.01	24	127.9	3,070	37,036
F	85/21	10.00	0.42	10.42	71.4	744	158	13.88	172	67.6	11,627	11.81	6.25	3.60	10.34	7.52	1.28	41	139.0	5,699	18,070
G	57/15	4.13	0.57	4.70	68.2	321	381	58.65	440	38.0	16,720	12.96	6.39	.97	.34	4.30	.93	26	106.2	2,761	19,802
J	60/12	33.68	0.55	34.23	68.5	2,345	521	168.57	590	14.0	8,260	49.90	12.48	19.84	45.42	19.12	5.98	153	82.5	12,623	23,228
K	52/15	8.37	0.88	9.25	63.3	586	135	22.29	157	65.0	10,205	7.50	4.38	3.42	10.01	4.12	1.66	31	128.3	3,987	14,768
Avg.	62/	$13.30	$0.64	$14.00	68.8	$ 950	$ 447	$ 79.14	$ 512	42.2	$18,544	$17.33	$ 6.71	$ 8.39	$15.21	$ 8.09	$2.40	$ 58	111.1	$ 5,874	$25,368
Private																					
B	49/9	$86.00	$0.27	$86.27	56.5	$4,874	$ 757	$ 27.27	$ 784	42.2	$33,084	$72.06	$54.72	$50.42	$94.66	$28.51	$2.74	$303	98.7	$29,906	$67,864
C	67/28	11.41	0.94	12.35	52.2	645	626	90.62	717	29.5	21,151	18.95	8.03	2.31	12.34	7.43	3.45	53	81.7	4,304	26,126
H	68/18	13.79	0.90	14.67	40.3	591	692	78.08	770	48.2	37,114	29.73	14.95	24.48	48.50	12.85	6.40	137	88.5	12,125	49,830
I	43/11	17.85	0.60	18.45	41.9	773	521	30.26	551	39.9	21,985	32.21	33.53	26.19	50.60	20.22	2.70	165	81.8	13,497	36,255
Avg.	57/	$32.26	$0.68	$33.00	47.7	$1,721	$ 649	$ 56.56	$ 706	40.0	$28,333	$38.24	$27.81	$25.85	$51.53	$17.25	$3.82	$165	87.6	$14,958	$45,012

TABLE 18 (Continued)

(c) Sociology

Universities	Size of Faculty / Department Graduate Enrollment	Non-Research Costs per Semester Hour: Teaching (faculty salary)	Non-Research Costs per Semester Hour: Space (classroom rental)	Non-Research Costs per Semester Hour: Total	Number of Non-Research Semester Hr in "Representative Curriculum"	Non-Research Cost of Training a Ph.D.	Research Costs per Semester Hour: Research Activity (salaries & equipment)	Research Costs per Semester Hour: Space (laboratory & student office)	Research Costs per Semester Hour: Total	Number of Research Semester Hr in Ph.D. "Representative Curriculum"	Research Cost of Training a Ph.D.	Supplemental Costs per Semester Hour: Administrative (salaries, faculty salaries, supplies)	Supplemental Costs per Semester Hour: Library	Supplemental Costs per Semester Hour: Departmental (supplies, clerical)	Supplemental Costs per Semester Hour: Fellowship	Supplemental Costs per Semester Hour: Staff Benefits	Supplemental Costs per Semester Hour: Faculty Office Costs	Supplemental Costs per Semester Hour: Total	Number of Total Semester Hr in Ph.D. "Representative Curriculum"	Supplemental Cost of Training a Ph.D.	Total Cost of Training a Ph.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
A	43/11	$19.27	$0.50	$19.77	63.1	$1,247	$ 541	$ 26.41	$ 567	23.3	$13,211	$13.46	$ 5.75	$ 7.08	$22.20	$ 9.73	$2.60	$ 61	86.4	$ 5,270	$19,728
B	35/10	44.42	0.27	44.69	70.5	3,151	739	8.42	747	20.8	15,537	31.10	19.45	7.81	45.46	13.67	1.49	119	91.3	10,865	29,553
C	45/16	8.47	0.94	9.41	73.0	687	547	76.02	623	7.7	4,897	9.25	5.99	0.34	2.27	4.61	2.18	25	80.7	2,017	7,601
D	42/10	6.27	0.90	7.17	56.3	404	173	24.25	197	18.6	3,664	15.72	3.56	0.63	10.44	2.84	1.45	35	74.9	2,621	6,689
E	55/17	5.53	0.64	6.17	86.0	531	762	58.55	821	25.5	20,935	3.48	2.54	0.68	0.63	2.65	0.76	11	111.5	1,226	22,692
F	51/18	18.21	0.42	18.63	67.0	1,248	382	18.54	401	34.1	13,674	11.62	4.21	2.92	3.86	6.71	1.29	31	101.1	3,134	18,056
G	92/21	9.02	0.57	9.59	64.9	622	362	38.12	400	36.7	14,680	27.45	2.17	2.65	1.55	6.63	1.38	42	101.6	4,267	19,569
H	19/11	24.45	0.90	25.35	64.7	1,640	345	16.49	361	25.1	9,061	16.26	5.80	4.83	25.56	9.58	5.77	68	89.8	6,106	16,807
I	116/23	27.72	0.36	28.08	56.5	1,586	1,440	18.33	1,458	8.7	12,684	41.89	39.25	4.53	35.38	20.77	1.47	143	65.2	9,323	23,593
J	125/16	7.53	0.55	8.08	74.8	604	264	30.06	294	8.6	2,528	5.59	3.10	0.48	3.66	3.07	0.88	17	83.4	1,418	4,550
K	82/13	6.47	0.88	7.35	64.1	471	87	2.21	89	34.0	3,026	7.66	5.85	2.17	13.86	3.14	1.29	34	98.1	3,332	6,829
Avg.	64/	$16.12	$0.63	$16.75	67.3	$1,108	$ 513	$ 28.85	$ 542	22.1	$10,349	$16.68	$ 8.88	$ 3.10	$14.99	$ 7.58	$1.87	$ 53	89.4	$ 4,508	$15,970
Public																					
A	43/11	$19.27	$0.50	$19.77	63.1	$1,247	$ 541	$ 26.41	$ 567	23.3	$13,211	$13.46	$ 5.75	$ 7.08	$22.20	$ 9.73	$2.60	$ 61	86.4	$ 5,270	$19,728
D	42/10	6.27	0.90	7.17	56.3	404	173	24.25	197	18.6	3,664	15.72	3.56	0.63	10.44	2.84	1.45	35	74.9	2,621	6,689
E	55/17	5.53	0.64	6.17	86.0	531	762	58.55	821	25.5	20,935	3.48	2.54	0.68	0.63	2.65	0.76	11	111.5	1,226	22,692
F	51/18	18.21	0.42	18.63	67.0	1,248	382	18.54	301	34.1	13,674	11.62	4.21	2.92	3.86	6.71	1.29	31	101.1	3,134	18,056
G	92/21	9.02	0.57	9.59	64.9	622	362	38.12	400	36.7	14,680	27.45	2.17	2.65	1.55	6.63	1.38	42	101.5	4,267	19,569
J	125/16	7.53	0.55	8.08	74.8	604	264	30.06	294	8.6	2,528	5.59	3.10	0.48	3.66	3.07	0.88	17	83.4	1,418	4,550
K	82/13	6.47	0.88	7.35	64.1	471	87	2.21	89	34.0	3,026	7.66	5.85	2.17	13.86	3.14	1.29	34	98.0	3,332	6,829
Avg.	70/	$10.33	$0.64	$11.00	68.0	$ 732	$ 367	$ 28.30	$ 381	25.8	$10,245	$12.14	$ 3.88	$ 2.37	$ 8.03	$ 4.97	$1.38	$ 33	93.8	$ 3,038	$14,007
Private																					
B	35/10	$44.42	$0.27	$44.69	70.5	$3,151	$ 739	$ 8.42	$ 747	20.8	$15,537	$31.10	$ 19.45	$ 7.81	$45.46	$13.67	$1.49	$119	91.3	$10,865	$29,553
C	45/16	8.47	0.94	9.41	73.0	687	547	76.02	623	7.7	4,897	9.25	5.99	0.34	2.27	4.61	2.18	25	80.7	2,017	7,601
H	19/11	24.45	0.90	25.35	64.7	1,640	345	16.49	361	25.1	9,061	16.26	5.80	4.83	25.56	9.58	5.77	68	89.7	6,106	16,807
I	116/23	27.72	0.36	28.08	56.5	1,586	1,440	18.33	1,458	8.7	12,684	41.89	39.25	4.53	35.38	20.77	1.47	143	65.3	9,323	23,593
Avg.	54/	$26.27	$0.62	$27.00	66.2	$1,766	$ 768	$ 29.82	$ 797	15.6	$10,545	$24.63	$ 17.62	$ 4.38	$27.17	$12.16	$2.73	$ 89	81.8	$ 7,080	$19,391

TABLE 18 (Concluded)

(d) English

Universities	Department Graduate Enrollment / Size of Faculty	Non-Research Costs per Semester Hour: Teaching (faculty salary)	Non-Research Costs per Semester Hour: Space (classroom rental)	Non-Research Costs per Semester Hour: Total	Number of Non-Research Semester Hr in "Representative Curriculum"	Non-Research Cost of Training a Ph.D.	Research Costs per Semester Hour: Research Activity (salaries & equipment	Research Costs per Semester Hour: Space (laboratory & student office)	Research Costs per Semester Hour: Total	Number of Research Semester Hr in Ph.D. "Representative Curriculum"	Research Cost of Training a Ph.D.	Supplemental Costs per Semester Hour: Administrative (salaries, faculty salaries, supplies)	Supplemental Costs per Semester Hour: Library	Supplemental Costs per Semester Hour: Departmental (supplies, clerical)	Supplemental Costs per Semester Hour: Fellowship	Supplemental Costs per Semester Hour: Staff Benefits	Supplemental Costs per Semester Hour: Faculty Office Costs	Supplemental Costs per Semester Hour: Total	Number of Total Semester Hr in Ph.D. "Representative Curriculum"	Supplemental Cost of Training a Ph.D.	Total Cost of Training a Ph.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
A	64/21	$11.76	$0.50	$12.26	64.8	$ 794	$ 44	$ 4.00	$ 48	29.1	$ 1,397	$ 9.81	$ 2.40	$ 3.71	$ 0.60	$ 4.41	$1.29	$ 22	93.9	$ 2,066	$ 4,257
B	152/14	20.73	0.27	21.00	56.1	1,178	67	6.93	74	41.4	3,064	22.62	22.82	2.04	20.73	6.50	0.57	75	97.5	7,313	11,555
C	79/24	6.19	0.94	7.13	71.0	506	485	137.16	622	7.2	4,478	7.15	5.61	0.32	2.50	3.53	1.74	21	78.2	1,642	6,626
D	88/21	5.82	0.90	6.72	61.0	410	327	76.22	403	14.2	5,723	10.39	4.14	0.76	5.51	3.72	1.68	26	75.2	1,955	8,088
E	353/14	13.26	0.64	13.90	97.8	1,359	135	80.52	216	29.4	6,350	17.85	31.77	4.86	6.74	5.40	1.15	68	127.2	8,649	16,358
F	252/31	20.72	0.42	21.14	72.9	1,541	147	2.94	150	40.3	6,045	15.66	11.80	5.85	3.99	7.10	1.19	45	113.2	5,094	12,680
G	153/21	7.50	0.57	8.07	61.6	497	512	141.66	654	29.0	18,966	18.69	2.77	0.48	0.24	4.93	0.99	28	90.6	2,537	22,000
H	151/26	23.07	0.90	23.97	55.8	1,338	216	69.92	286	14.7	4,204	33.07	15.63	2.49	21.84	9.30	4.36	87	70.5	6,134	11,676
I	170/36	20.24	0.37	20.61	57.1	1,177	279	21.32	300	5.6	1,680	42.35	22.05	1.92	15.17	12.09	0.90	94	62.7	5,894	8,751
J	318/22	24.57	0.55	25.12	75.5	1,897	91	81.00	172	12.7	2,202	15.53	12.67	2.52	5.13	6.25	1.81	44	88.2	3,881	7,980
K	216/36	12.89	0.88	13.77	48.6	669	144	36.60	181	46.4	8,398	12.15	8.59	2.10	2.94	4.65	1.98	32	95.0	3,040	12,107
Avg.	181/	$15.16	$0.63	$15.79	65.6	$1,033	$ 222	$ 59.84	$ 282	24.5	$ 5,682	$18.66	$12.75	$ 2.46	$ 7.76	$ 6.17	$1.61	$ 49	90.1	$ 4,382	$11,098
Public																					
A	64/21	$11.76	$0.50	$12.26	64.8	$ 794	$ 44	$ 4.00	$ 48	29.1	$ 1,397	$ 9.81	$ 2.40	$ 3.71	$ 0.60	$ 4.41	$1.29	$ 22	93.9	$ 2,066	$ 4,257
D	88/21	5.82	0.90	6.72	61.0	410	327	76.22	403	14.2	5,723	10.39	4.14	0.76	5.51	3.72	1.68	26	75.2	1,955	8,088
E	353/14	13.26	0.64	13.90	97.8	1,359	135	80.52	216	29.4	6,350	17.85	31.77	4.86	6.74	5.40	1.15	68	127.2	8,649	16,358
F	252/31	20.72	0.42	21.14	72.9	1,541	147	2.94	150	40.3	6,045	15.66	11.80	5.85	3.99	7.10	1.19	45	113.2	5,094	12,680
G	153/21	7.50	0.57	8.07	61.6	497	512	141.66	654	29.0	18,966	18.69	2.77	0.48	0.24	4.93	0.99	28	90.6	2,537	22,000
J	318/22	24.57	0.55	25.12	75.5	1,897	91	81.00	172	12.7	2,202	15.53	12.67	2.52	5.13	6.25	1.81	44	88.2	3,881	7,980
K	216/36	12.89	0.88	13.77	48.6	669	144	36.60	181	46.4	8,398	12.15	8.59	2.10	2.94	4.65	1.98	32	95.0	3,040	12,107
Avg.	206/	$13.79	$0.64	$14.42	68.9	$1,024	$ 200	$ 60.42	$ 261	28.7	$ 7,020	$14.30	$10.59	$ 2.90	$ 3.59	$ 5.21	$1.44	$ 38	97.6	$ 3,888	$11,923
Private																					
B	152/14	$20.73	$0.27	$21.00	56.1	$1,178	$ 67	$ 6.93	$ 74	41.4	$ 3,064	$22.62	$22.82	$ 2.04	$20.73	$ 6.50	$0.57	$ 75	97.5	$ 7,313	$11,555
C	79/24	6.19	0.94	7.13	71.0	506	485	137.16	622	7.2	4,478	7.15	5.61	0.32	2.50	3.53	1.74	21	78.2	1,642	6,626
H	151/26	23.07	0.90	23.97	55.8	1,338	216	69.92	286	14.7	4,204	33.07	15.63	2.49	21.84	9.30	4.36	87	70.5	6,134	11,676
I	170/36	20.24	0.37	20.61	57.1	1,177	279	21.32	300	5.6	1,680	42.35	22.05	1.92	15.17	12.09	0.90	94	62.7	5,894	8,751
Avg.	138/	$17.56	$0.62	$18.00	60.0	$1,050	$ 262	$ 58.83	$ 321	17.2	$ 3,357	$26.30	$21.22	$ 1.68	$15.06	$ 7.86	$1.89	$ 69	77.2	$ 5,247	$ 9,653

TABLE 19

COMPUTATION OF COST OF THE RESEARCH PHASE OF GRADUATE STUDY: FOUR DISCIPLINES

	Faculty Salary Cost of Research Time					Faculty Salary Cost of Graduate Student Supervision					Cost of Sponsored Research Projects Allocated to Graduate Training					
Universities	Percent Time (Faculty) Spent on Research	Total Graduate Faculty Salary	Total Faculty Research Cost	Total Research Credit Hours Produced by Department—1964-65	Faculty Salary Cost of Research Time per Research Credit Hour	Percent Time (Faculty) Spent on Graduate Student Supervision	Total Graduate Faculty Salary	Total Faculty Supervision Cost	Total Research Credit Hours Produced by Department—1964-65	Faculty Salary Cost of Graduate Student Supervision per Research Credit Hour	Total Cost of Sponsored Research Conducted by Graduate Faculty	Average Allocation Ratio	Allocated Portion of Total Research Expenditures	Total Graduate Student Research Credit Hours Produced—1964-65	Sponsored Research Cost per Graduate Student Research Credit Hour	Total Research Cost per Research Credit Hour (excluding laboratory space and supplemental costs—sum of columns 5, 10, and 15)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
								Physics								
A	29	$212,280	$ 61,551	423	$146.00	19	$212,280	$40,333	423	$ 95.00	$ 687,841	.298	$204,977	423	$ 485	$ 726
B	34	165,075	56,126	472	41.97	24	165,075	39,618	472	84.00	967,407	.298	288,287	472	611	737
C	43	110,500	47,515	193	246.19	9	110,500	9,945	193	52.00	101,180	.298	30,151	193	156	454
D	36	296,736	106,824	222	481.00	12	296,736	35,608	222	160.00	1,167,943	.298	348,047	222	1,568	2,209
E	44	164,325	72,303	233	310.00	15	164,325	24,649	233	106.00	1,364,015	.298	406,476	233	1,745	2,161
F	38.8	453,888	176,109	2,464	72.00	16.5	453,888	74,891	2,464	30.00	1,163,211	.298	346,637	2,464	141	244
G	42	231,650	97,293	678	142.00	16	231,650	37,064	678	55.00	327,251	.298	97,521	678	144	512
H	39	159,012	62,015	615	100.84	18	159,012	28,622	615	47.00	978,146	.298	291,488	615	474	933
I	54	493,079	266,263	1,115	238.80	17	493,079	83,823	1,115	75.00	----	.298	----	1,115	----	554
J	41	316,527	129,776	694	187.00	13	316,527	41,149	694	59.00	733,830	.298	218,690	694	315	842
K	28	320,398	90,714	1,747	52.00	21	320,398	67,284	1,747	39.00	994,557	.298	296,372	1,747	170	392
								Zoology								
A	33	$262,550	$ 86,642	302	$287.00	9	$262,550	$23,630	302	$ 78.00	$ 497,184	.196	$ 97,448	302	$ 323	$ 688
B	29	127,775	37,055	185	200.00	9	127,775	11,500	185	62.00	467,219	.196	91,575	185	495	757
C	36	287,976	103,671	305	340.00	9	287,967	25,918	305	85.00	313,242	.196	61,395	305	201	626
D	28	171,600	48,048	132	364.00	6	171,600	10,296	132	78.00	80,734	.196	15,824	132	120	562
E	38	128,790	48,940	126	388.00	10	128,790	12,879	126	102.00	126,482	.196	24,790	126	197	687
F	36.4	249,866	90,951	1,138	80.00	8.9	249,866	22,238	1,138	20.00	334,534	.196	65,569	1,138	58	158
G	38	195,300	74,214	465	160.00	10	195,300	19,530	465	42.00	123,372	.196	24,181	465	52	381
H	44	238,053	104,743	582	180.00	9	238,053	21,425	582	37.00	725,288	.196	142,156	582	244	692
I	53	169,780	89,983	510	177.00	10	169,780	16,978	510	33.00	----	.196	----	--	----	----
J	30	135,505	40,652	148	275.00	9	135,505	12,195	148	82.00	----	----	----	--	----	----
K	35	161,154	56,404	1,155	49.00	8	161,154	12,892	1,155	11.00	176,146	.196	34,524	1,155	30	135
								Sociology								
A	40	$130,100	$ 52,040	150	$347.00	5	$130,100	$ 6,505	150	$ 43.00	$ 110,126	.205	$ 22,576	150	$ 151	$ 541
B	30	128,540	38,562	195	198.00	7	128,540	8,998	195	461.00	75,638	.205	15,506	195	80	739
C	30	160,020	48,006	111	432.00	7	160,020	11,201	111	101.00	7,681	.205	1,575	111	14	547
D	30	113,900	34,170	276	124.00	8	113,900	9,112	276	33.00	21,217	.205	4,349	276	16	173
E	35	162,300	56,805	99	574.00	4	162,300	6,492	99	66.00	59,019	.205	12,099	99	122	762
F	33.3	190,452	63,420	232	273.00	8.6	190,452	16,379	232	71.00	42,545	.205	8,722	232	38	382
G	27	274,850	74,210	543	137.00	8	274,850	21,988	543	40.00	170,251	.205	34,901	543	64	362
H	47	124,800	58,656	350	167.00	10	124,800	12,480	350	36.00	46,623	.205	9,558	350	27	345
I	51	384,592	196,142	605	324.00	10	384,592	38,459	605	64.00	90,527	.205	18,557	605	31	1,440
J	36	195,297	70,307	786	89.00	7	195,297	13,671	786	17.00	269,142	.205	55,174	786	70	264
K	21	133,329	27,999	835	34.00	15	133,329	19,999	835	24.00	----	.205	----	835	----	87
								English								
A	22.1	$226,900	$ 50,144	1,474	$ 34.00	6.6	$226,900	$14,975	1,474	$ 10.00	----	----	----	--	----	$ 44
B	21	202,450	42,514	960	44.00	11	202,450	22,270	960	23.00	----	----	----	--	----	67
C	20	227,700	45,540	108	422.00	3	227,700	6,831	108	63.00	----	----	----	--	----	485
D	17	274,125	46,601	184	253.00	5	274,125	13,706	184	74.00	----	----	----	--	----	327
E	35	152,289	53,301	462	115.00	6	152,289	9,137	462	20.00	----	----	----	--	----	135
F	22.1	366,182	80,926	717	113.00	6.6	366,182	24,168	717	34.00	----	----	----	--	----	147
G	24	258,965	62,152	243	256.00	8	258,965	20,717	243	85.00	----	----	----	--	----	512
H	18	350,350	63,063	656	96.00	9	350,350	31,532	656	48.00	----	----	----	--	----	216
I	19	584,164	110,991	785	141.00	6	584,164	35,050	785	45.00	----	----	----	--	----	279
J	16	261,950	41,909	742	56.00	6	261,950	15,716	742	35.00	----	----	----	--	----	91
K	27	375,233	101,313	1,328	76.00	7	375,233	26,266	1,328	20.00	----	----	----	--	----	144

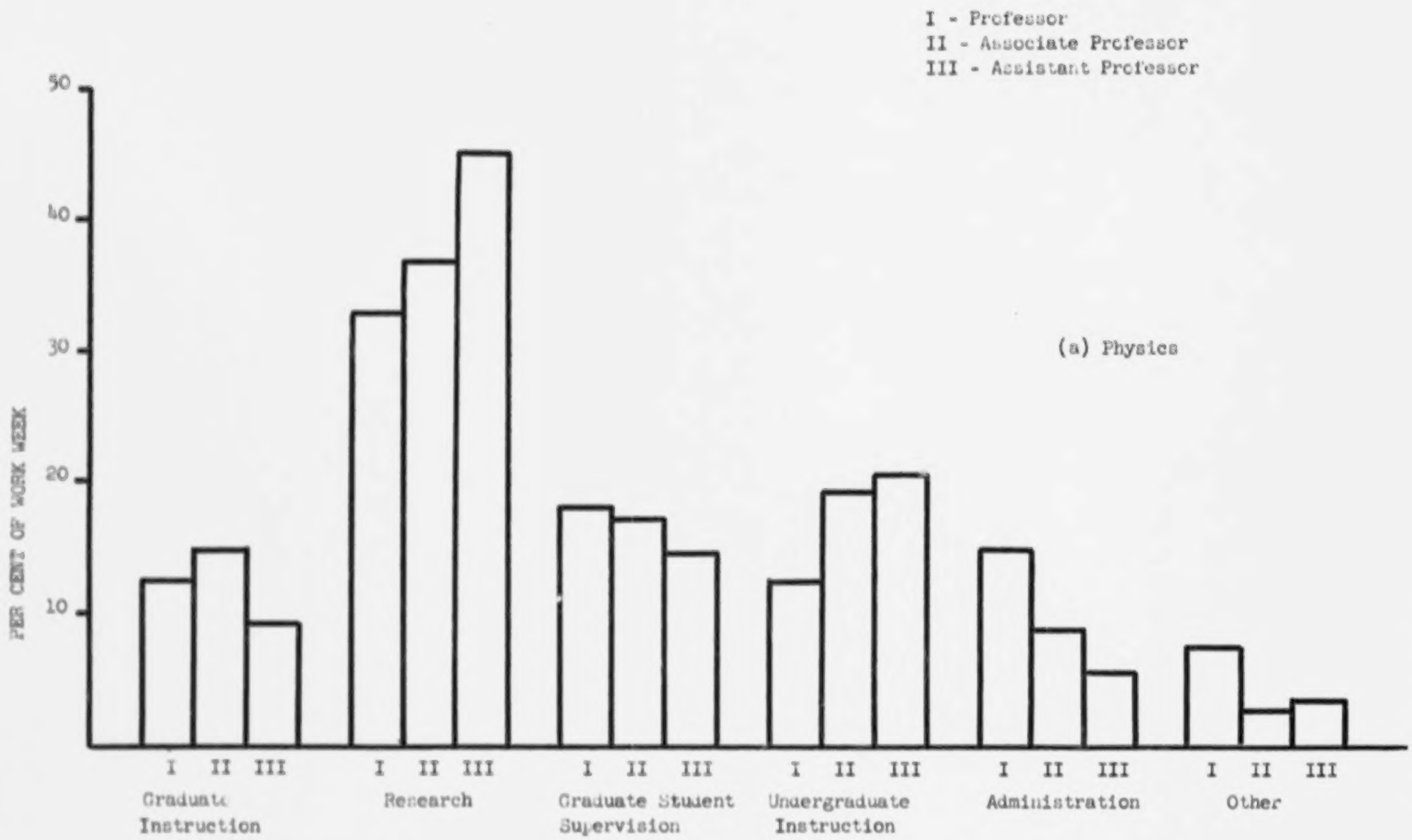


Figure 3. Graduate faculty time distribution (in percent) by rank.

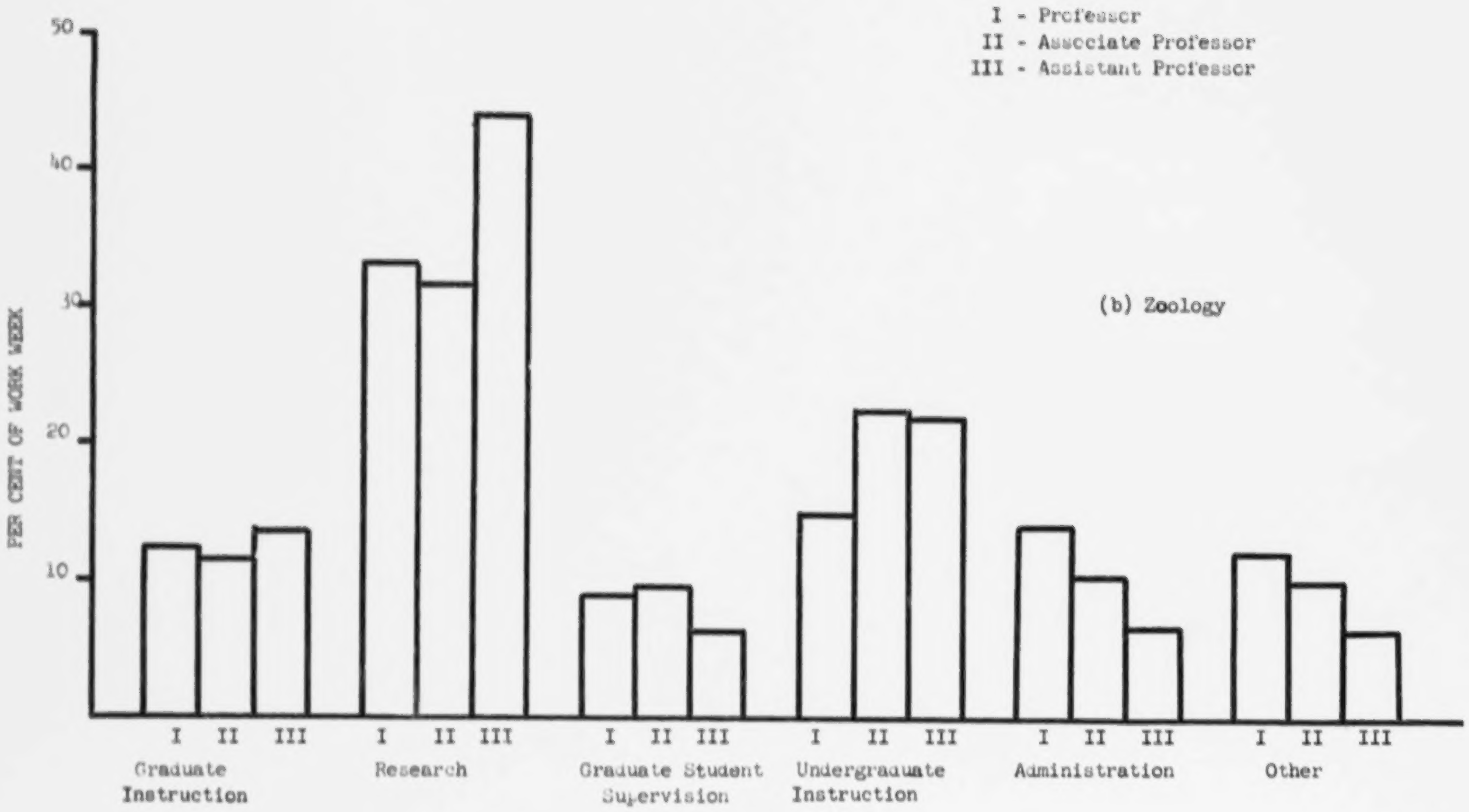


Figure 3. (Continued)

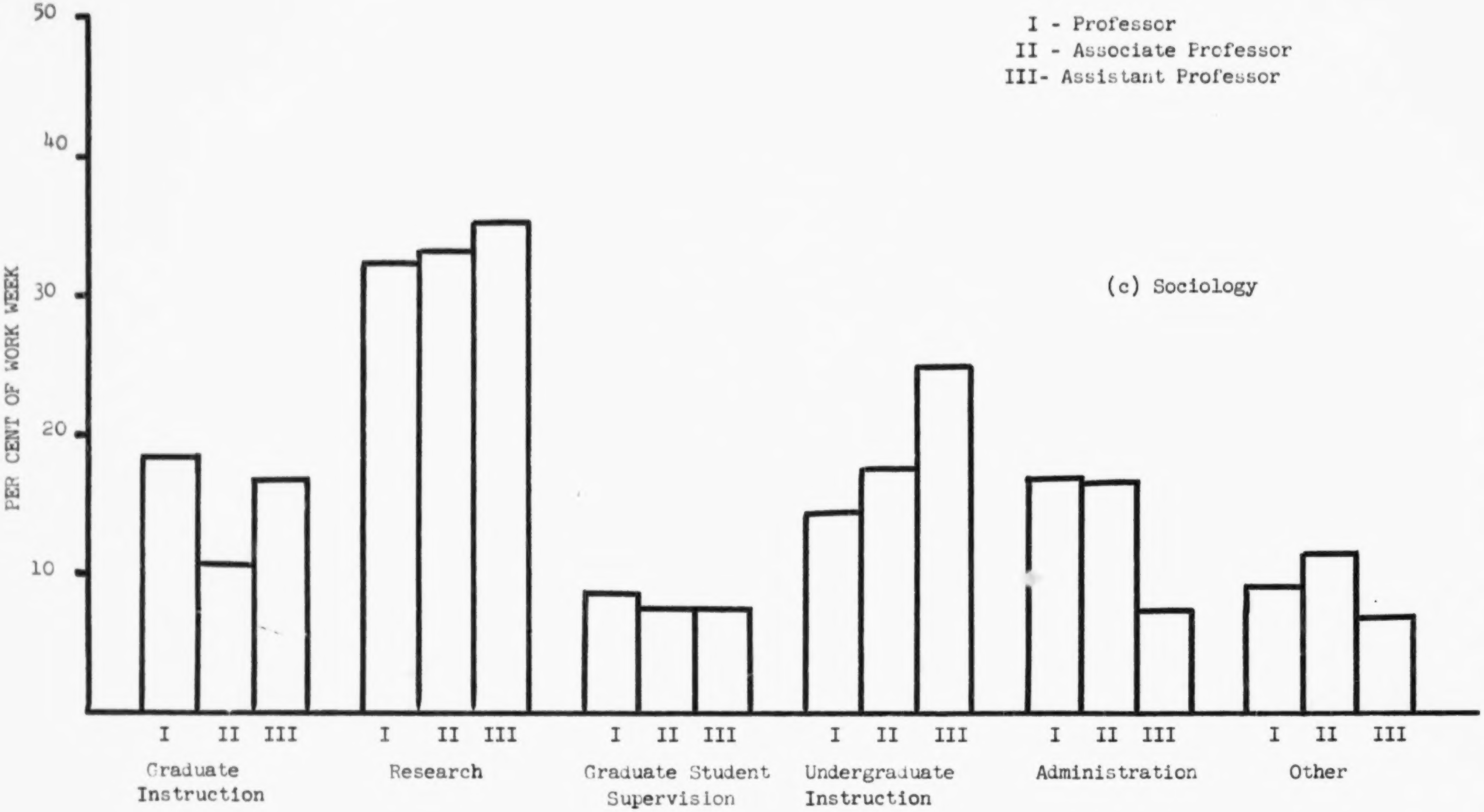

(c) Sociology

Figure 3. (Continued)

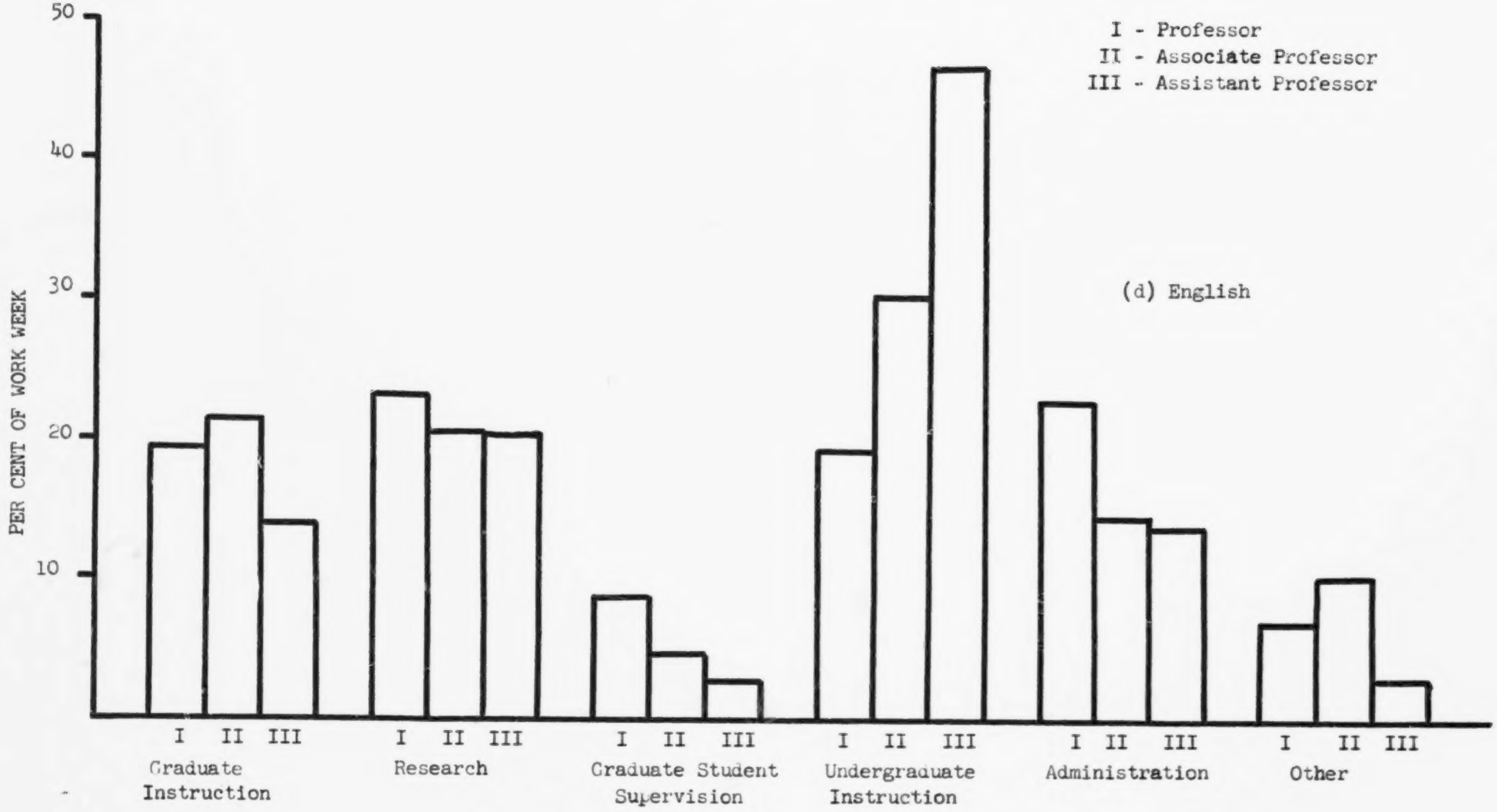


Figure 3. (Concluded)

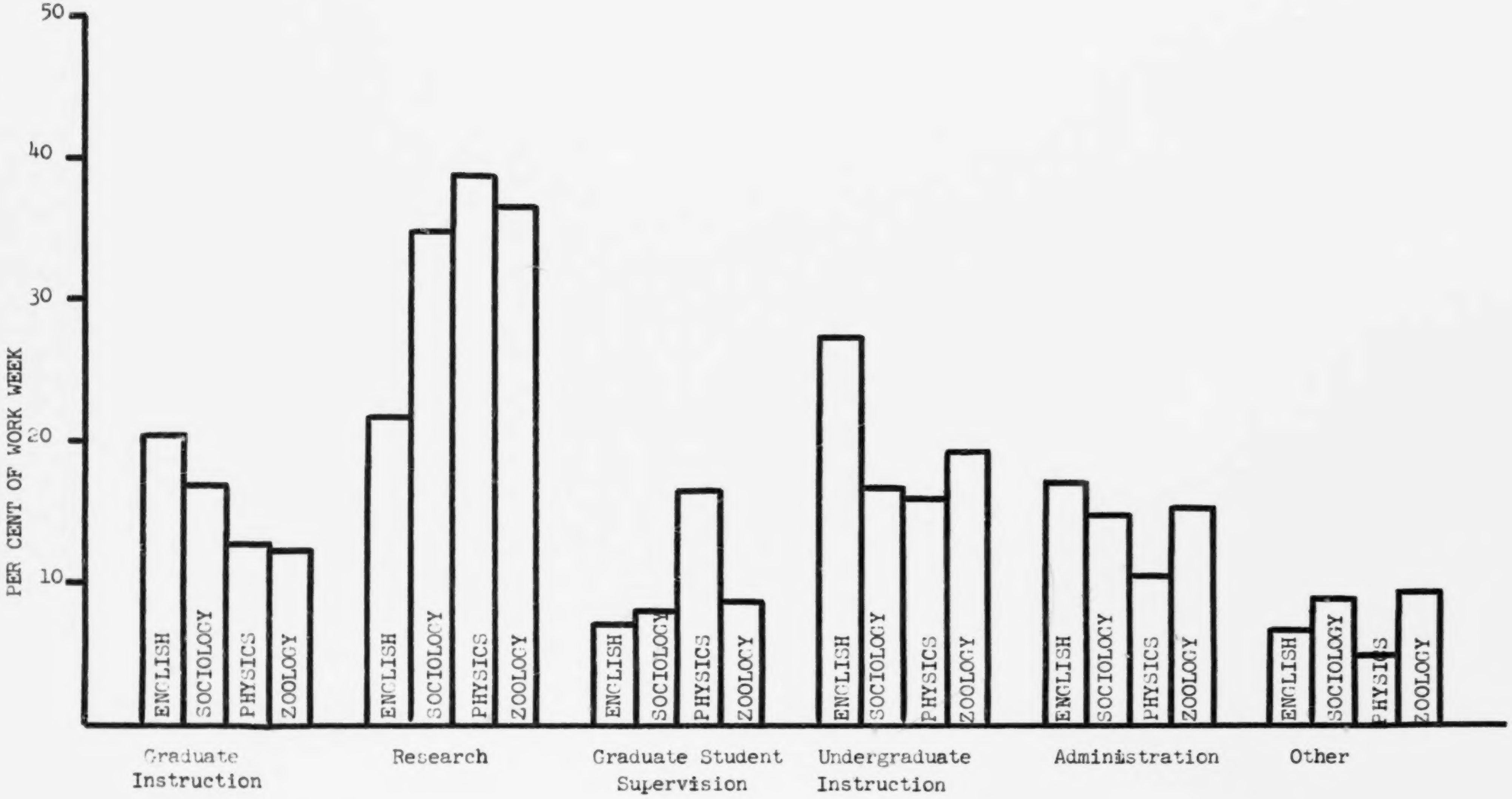
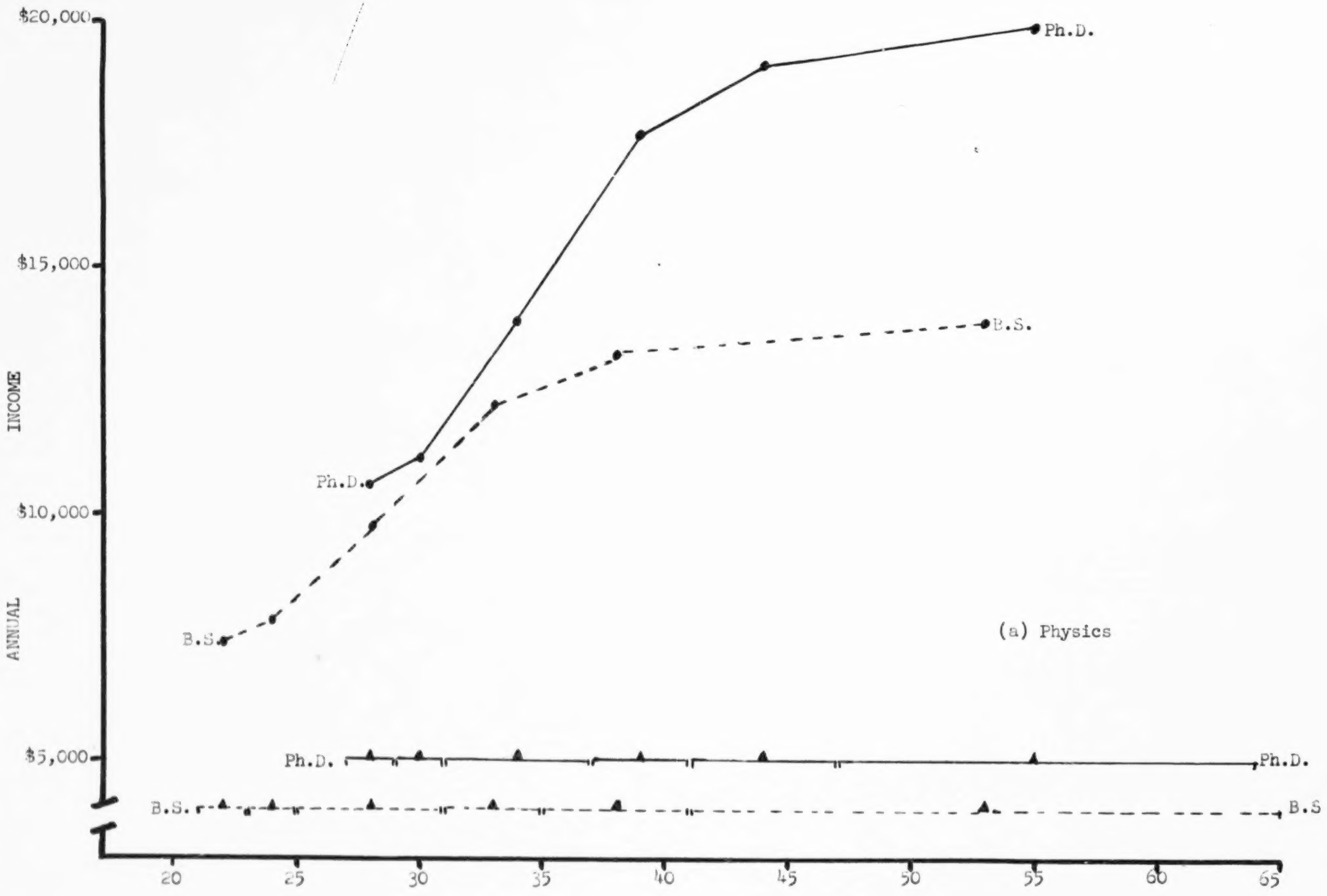
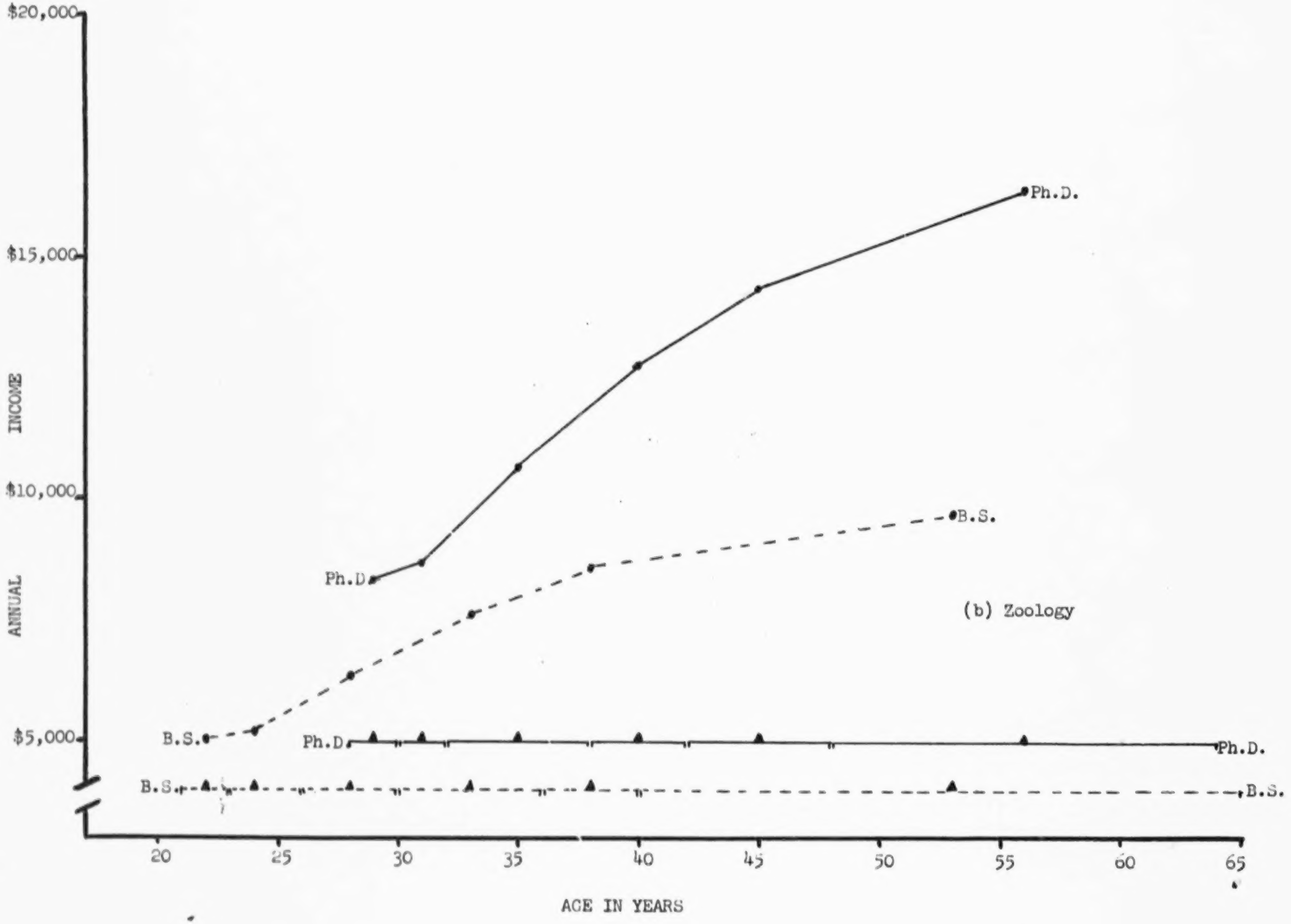


Figure 4. Graduate faculty time distribution compared in four disciplines.



(a) Physics

Figure 5. Projected earnings profiles.



(b) Zoology

Figure 5. (Continued)

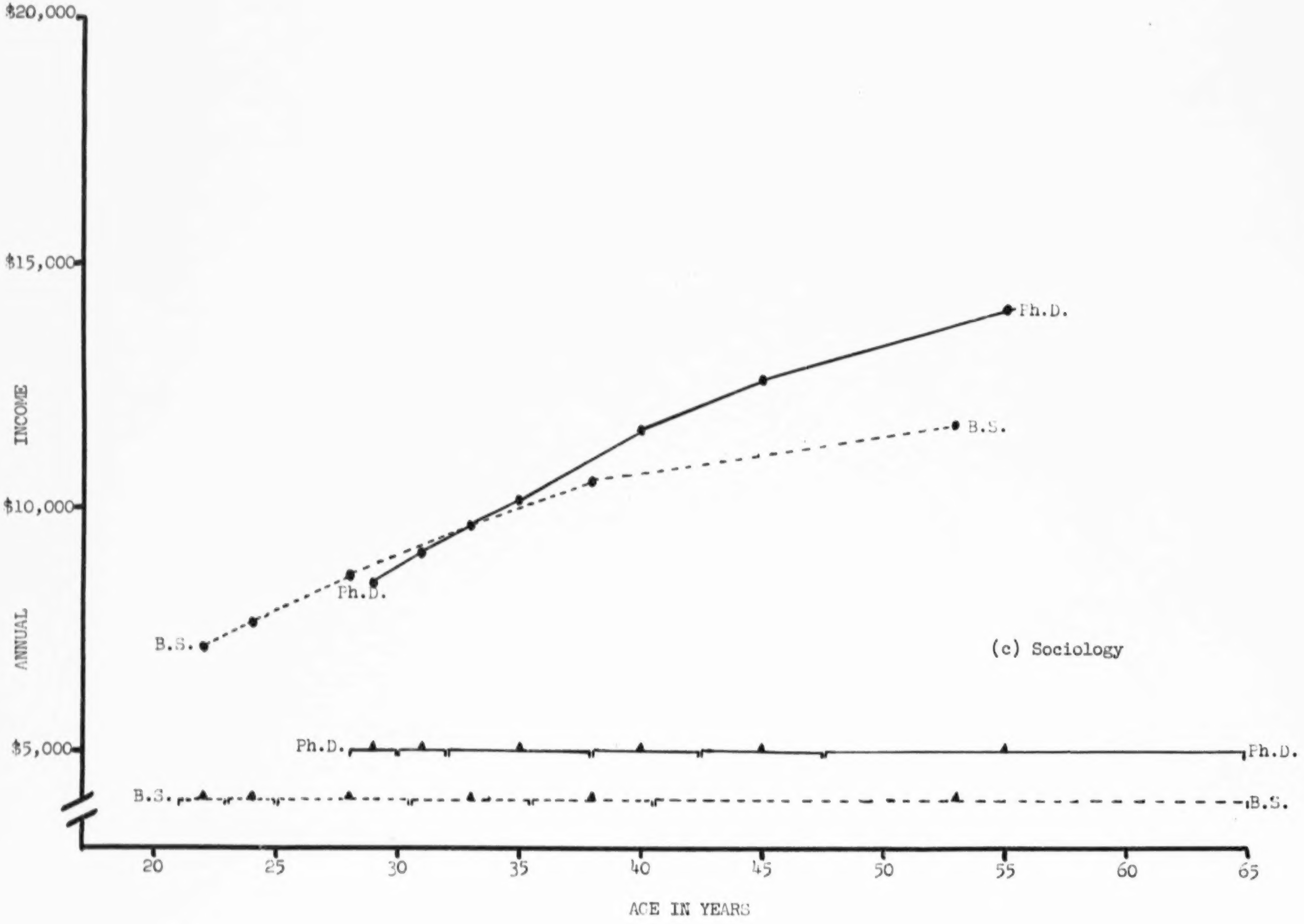

(c) Sociology

Figure 5. (Continued)

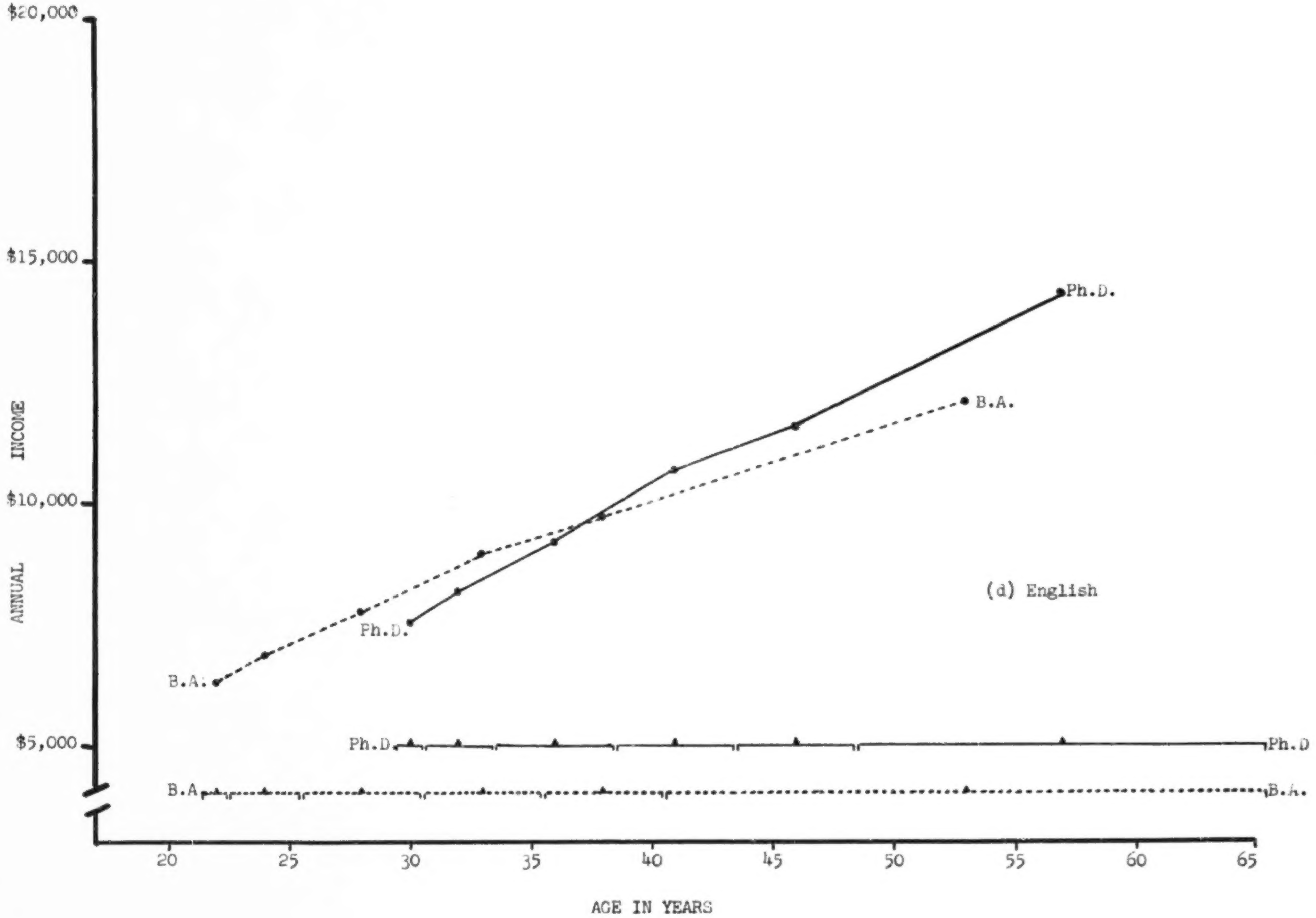


Figure 5. (Concluded)

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